U.PORTO

MASTER IN ECONOMICS OF BUSINESS AND STRATEGY

Interorganizational collaboration and innovation-related outcomes in Portuguese firms: Evidence from the Community Innovation Survey

Marcelo Moutinho

M

2026



U.PORTO
FEP FACULDADE DE ECONOMIA E GESTÃO UNIVERSIDADE DO PORTO

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Dissertation
Master in Economics of Business and Strategy

Supervised by
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2026

Declaration of Honour

I declare that this dissertation is my own work and has not previously been published, submitted or assessed at this or any other institution. All ideas, statements and materials drawn from other authors are appropriately acknowledged and referenced in accordance with the applicable academic standards. I am aware that plagiarism and self-plagiarism constitute academic misconduct under the Code of Ethics of the University of Porto.

Generative artificial intelligence tools were used as support during the preparation of this dissertation for language refinement, editorial review, document structuring, consistency checking, and assistance in reviewing the presentation and interpretation of analytical outputs. These tools were not treated as sources of scientific evidence and did not replace human authorship or critical judgement. The empirical data preparation and estimations were executed by the author in Stata, and all substantive claims, numerical results, citations and AI-assisted text incorporated into the dissertation were critically reviewed and verified against the relevant literature, CIS documentation and statistical outputs.

I assume full responsibility for the content, methodological choices, analysis, interpretations and conclusions presented in this dissertation.

Acknowledgements

I would like to begin by expressing my sincere gratitude to my supervisors, Professor Fátima São Simão and Professor Anabela Carneiro, for their guidance, availability and rigor throughout the development of this dissertation. Their feedback and complementary perspectives were fundamental in refining both the theoretical and empirical dimensions of this work.

I am also grateful to the School of Economics and Management of the University of Porto for the academic environment and resources that supported my master's journey and the development of this research.

I am especially grateful to my manager for the flexibility, trust and autonomy he gave me while I completed this dissertation alongside my professional responsibilities.

I am also deeply grateful to my family for the constant support, trust and encouragement that have accompanied me throughout my academic path.

My thanks also go to my friends who were part of this journey, for their encouragement, companionship and for the many moments that provided a necessary balance beyond academic work.

Finally, to my partner, I owe my deepest thanks for her patience, understanding and unwavering support. Having someone beside me who shared both the pressure and the satisfaction of this journey made the difficult moments easier and the achievements more meaningful.

This dissertation marks the end of an important stage of my academic life, and I am deeply grateful to everyone who, in different ways, helped me reach it.

Resumo

Esta dissertação analisa como a participação na cooperação para a inovação e a abrangência da colaboração se associam a diferentes resultados de inovação nas empresas portuguesas abrangidas pelo Community Innovation Survey (CIS). As vagas harmonizadas de 2018, 2020 e 2022 são combinadas como cortes transversais repetidos, totalizando 41.012 observações empresa-vaga. Estimam-se modelos logit binário, ordenado e multinomial para três resultados: inovação de produto nova para o mercado, importância estratégica da introdução de novos bens ou serviços e um perfil nominal de inovação de produto que distingue nenhuma, exatamente uma ou ambas as categorias do CIS. Nas estimativas combinadas, a participação na cooperação associa-se a probabilidades médias previstas superiores em 13,78 pontos percentuais para a inovação de produto nova para o mercado e em 9,48 pontos percentuais para elevada importância estratégica. Cada combinação adicional de tipo de parceiro/localização associa-se a aumentos de 0,72 e 1,05 pontos percentuais, respetivamente, nessas probabilidades. Ambas as dimensões da colaboração associam-se também a uma menor probabilidade prevista de não reportar nenhuma categoria de inovação de produto e a maiores probabilidades de reportar exatamente uma ou ambas. As estimações por vaga e os testes de sensibilidade com especificações separadas corroboram, em geral, os resultados combinados, embora a associação entre abrangência e o perfil de exatamente uma categoria seja menos robusta entre vagas e na especificação apenas com abrangência. O estudo fornece evidência recente ao nível da empresa e reforça a utilidade de distinguir participação, abrangência da colaboração e múltiplos resultados de inovação. Dado o desenho de cortes transversais repetidos, as estimativas são interpretadas como associações condicionais, e não como efeitos causais.

Palavras-chave: Inovação aberta; Colaboração interorganizacional; Abrangência da colaboração; Inovação de produto; Community Innovation Survey; Portugal.

Abstract

This dissertation examines how participation in innovation cooperation and collaboration breadth are associated with different innovation-related outcomes among Portuguese enterprises covered by the Community Innovation Survey (CIS). The three harmonized CIS waves for 2018, 2020 and 2022 are pooled as repeated cross-sections, yielding 41,012 enterprise-wave observations. Binary, ordered and multinomial logit models examine three outcomes: market-new product innovation, the strategic importance of introducing new goods or services, and a nominal product-innovation profile distinguishing neither, exactly one, or both CIS product-innovation categories. In the pooled models, participation in innovation cooperation is associated with a 13.78 percentage-point higher average predicted probability of market-new product innovation and a 9.48 percentage-point higher probability of assigning high strategic importance to introducing new goods or services. Each additional partner-type/location combination is associated with increases of 0.72 and 1.05 percentage points in these respective probabilities. Both collaboration dimensions are also associated with a lower predicted probability of reporting neither product-innovation category and higher predicted probabilities of reporting exactly one or both categories. Wave-specific estimations and separate-specification sensitivity checks broadly reinforce the pooled evidence, although the breadth association with the exactly-one profile is less robust across individual waves and in the breadth-only specification. The study provides recent firm-level evidence across three harmonized CIS waves and highlights the value of distinguishing participation in innovation cooperation from collaboration breadth and considering multiple innovation outcomes. Given the repeated cross-sectional design, the estimates are interpreted as conditional associations rather than causal effects.

Keywords: Open innovation; Interorganizational collaboration; Collaboration breadth; Product innovation; Community Innovation Survey; Portugal.

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List of Abbreviations

ACAP	Absorptive capacity
AME	Average marginal effect
CAE	Portuguese Classification of Economic Activities (CAE Rev. 3)
CIS	Community Innovation Survey
EIS	European Innovation Scoreboard
EU	European Union
FDI	Foreign Direct Investment
HRST	Human resources in science and technology
IIA	Independence of irrelevant alternatives
NUTS II	Nomenclature of Territorial Units for Statistics, level 2
OI	Open innovation
PACAP	Potential absorptive capacity
R&D	Research and Development
RACAP	Realized absorptive capacity
SME	Small and medium-sized enterprise
VIF	Variance inflation factor

1. Introduction

Innovation is widely understood as an interactive and knowledge-based process in which firms draw on ideas, resources and capabilities distributed across organizational boundaries. This perspective underpins open innovation (OI), which emphasizes purposively managed knowledge flows between firms and external actors (Chesbrough, 2003; West & Bogers, 2014). External engagement can broaden access to technological and market knowledge, but its benefits are neither automatic nor uniform: collaboration may generate coordination costs, while firms differ in their ability to recognize, assimilate and exploit externally sourced knowledge (Cohen & Levinthal, 1990; Faems et al., 2010; Laursen & Salter, 2006). The relevant empirical question is therefore not simply whether firms collaborate, but how different dimensions of collaborative engagement are associated with different innovation-related outcomes.

This question is particularly relevant in Portugal. Existing firm-level studies document the relevance of external knowledge and interorganizational engagement to innovation, but the available evidence is dispersed across periods, sectors, firm populations and operationalizations of openness (Ademuyiwa et al., 2025; Almeida, 2021, 2024; Cesário & Fernandes, 2019; Fernandes et al., 2017; Nunes et al., 2019; Teixeira & Lopes, 2012). Several contributions focus on SMEs, specific sectors or individual survey periods (Ademuyiwa et al., 2025; Almeida, 2021, 2024; Cesário & Fernandes, 2019). Recent institutional indicators reinforce this motivation: Portugal performs relatively strongly on some innovation indicators, while the specific indicator for innovative SMEs collaborating with others remains below the EU average (European Commission, 2026, p. 3). Consequently, recent firm-level evidence remains limited on how different dimensions of innovation cooperation relate to different innovation outcomes within a common empirical framework across the economic activities covered by the CIS.

The Community Innovation Survey (CIS) allows the study to distinguish whether enterprises cooperate on R&D or other innovation activities and how widely these relationships extend across partner types and geographical locations (European Commission & Eurostat, n.d., 2018, 2022). Participation captures whether active cooperation occurs, whereas collaboration breadth captures its reported scope. Because breadth is structurally zero for non-cooperating enterprises, the two measures are interpreted as complementary features of the same collaboration profile. This distinction matters because the value of

external engagement varies with breadth, prior experience, partner configuration, organizational context and the innovation outcome considered (Belderbos et al., 2004; Ebersberger et al., 2021; Laursen & Salter, 2006; Love et al., 2014).

The study deliberately adopts a broad cross-industry scope rather than restricting the analysis to a particular sector. This choice follows from the research objective and from the Portuguese literature, where several contributions are sector-specific, SME-focused or based on individual survey periods (Ademuyiwa et al., 2025; Almeida, 2021, 2024; Cesário & Fernandes, 2019). CAE Rev. 3 division effects are included in the pooled specifications to account for systematic differences across sectors, although the study does not estimate sector-specific collaboration relationships. The analysis is likewise not restricted to a particular region because the research question concerns firm-level associations across the Portuguese CIS sample rather than regional heterogeneity. Sectoral and regional differences may remain relevant, but their separate estimation lies beyond the scope of the present study.

Accordingly, the dissertation aims to assess to what extent participation in innovation cooperation and collaboration breadth are associated with different innovation-related outcomes among Portuguese enterprises covered by the CIS. The resulting research question is:

To what extent are participation in innovation cooperation and collaboration breadth associated with different innovation-related outcomes among Portuguese enterprises covered by the CIS?

A single innovation measure would not capture all dimensions relevant to this question. The dissertation therefore considers three distinct but related outcomes. Market-new product innovation captures realized product novelty relative to competitors (OECD/Eurostat, 2018). The strategic importance attributed to introducing new goods or services captures the importance assigned to this objective for the enterprise's economic performance and is conceptually distinct from realized business performance (Siguaw et al., 2006; Venkatraman & Ramanujam, 1986). Finally, a nominal product-innovation profile distinguishes enterprises reporting neither, exactly one or both CIS product-innovation categories. These profiles are treated as qualitatively different configurations of reported innovation activity rather than as an ordered hierarchy of innovation performance. The three outcomes therefore allow the analysis to assess whether the relationship with collaboration varies according to the innovation dimension considered.

The empirical analysis uses anonymized scientific-use microdata from the Portuguese CIS 2018, 2020 and 2022. The CIS target population covers enterprises with at least 10

persons employed across the survey's eligible economic activities (Eurostat, 2020, 2022, 2024). The three scientific-use datasets are harmonized and pooled as repeated cross-sections, yielding 41,012 enterprise-wave observations. Because the final specifications are unweighted, the estimates are not interpreted as population-representative estimates for Portuguese enterprises. Binary, ordered and multinomial logit models are estimated according to the nature of the three dependent variables, with common firm-level controls, CAE Rev. 3 division effects and CIS-wave effects. Average marginal effects provide the main basis for substantive interpretation, while wave-specific re-estimations and separate-specification sensitivity checks are used to assess robustness. Given the repeated cross-sectional design and the possibility of selection into cooperation, omitted firm characteristics and reverse causality, the estimates are interpreted as conditional associations rather than causal effects.

The pooled estimates show a consistent directional pattern. Participation in innovation cooperation and collaboration breadth are associated with higher probabilities of market-new product innovation and high strategic importance, as well as a lower probability of reporting neither product-innovation category and higher probabilities of reporting exactly one or both categories. The breadth association with the exactly-one profile is less robust across individual waves and in the breadth-only sensitivity specification, whereas its positive association with the both-category profile remains robust.

The dissertation contributes by providing recent firm-level evidence for Portuguese enterprises covered by the CIS across three harmonized survey waves, distinguishing participation in innovation cooperation from collaboration breadth and examining both dimensions across multiple innovation-related outcomes rather than a single innovation indicator. Chapter 2 develops the theoretical and empirical background and reviews the evidence relevant to Portugal. Chapter 3 presents the empirical methodology, integrating the research gap and hypotheses with the data, variable definitions and econometric models. Chapter 4 reports and discusses the empirical results and robustness checks. Chapter 5 concludes with the main findings and contribution, implications, limitations and directions for future research.

2. Literature Review

2.1. Innovation: theoretical foundations

2.1.1. The evolution of innovation theory

Given the diversity of approaches in the literature, establishing a clear and grounded definition of innovation is essential. In this context, the Oxford Handbook of Innovation offers a widely accepted conceptual reference, with Fagerberg's distinction providing a helpful analytical starting point: "Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice" (Fagerberg, 2005, p. 4). Building on the foundations of innovation theory, Schumpeter (1934) conceptualized innovation as the creation of new combinations of existing resources, encompassing new products, processes, markets, and organizational forms, while also emphasizing the resistance entrepreneurs often face when introducing change.

Over time, the Schumpeterian view of innovation as a dynamic process contrasted with linear models that depicted innovation as a sequential progression from scientific discovery to market application. Such representations were later reconsidered through the chain-linked model proposed by Kline and Rosenberg (1986), which emphasized the presence of iterative feedback loops between research, development, production, and market use rather than a unidirectional flow. Within this non-linear perspective, innovative activity was further conceptualized as operating within technological paradigms that define relevant problems and problem-solving procedures, thereby guiding search processes along specific trajectories (Dosi, 1988). Innovation, in this sense, becomes cumulative and structured by shared cognitive and technical frameworks. Historical analysis also shows that increasing returns and contingent events may reinforce particular technological standards over time, leading to path-dependent outcomes and potential lock-in (David, 1985). Collectively, these perspectives demonstrate that innovation unfolds within historically and technologically conditioned trajectories rather than through isolated and sequential stages.

Beyond technological trajectories and path-dependent developments, innovation has also been conceptualized as a process grounded in interactive learning and knowledge creation. From this perspective, innovation is shaped by ongoing interactions between producers and users, where learning occurs through repeated exchanges embedded in institutional and economic contexts (Lundvall, 1992). Innovative activity, therefore, is not confined to isolated research efforts but emerges from communication and cooperation

among firms and other actors within systems of innovation. At the organizational level, innovation depends on the dynamic interaction between tacit and explicit knowledge, through which new knowledge is generated by converting individual insights into shared organizational understanding (Nonaka, 1991). Extending the scope beyond individual firms, agents frequently constitute important sources of innovation, particularly when they face needs that precede those of the broader market, contributing to distributed problem-solving activities across organizational boundaries (von Hippel, 1988).

At a broader institutional level, Freeman (1995) places innovation within national systems of innovation, arguing that technological development and economic performance are shaped by the institutional configuration linking firms, universities, government agencies, and financial systems. Consistent with this systemic perspective, Powell et al. (1996) observe that innovation increasingly takes place within interorganizational networks, where collaborative relationships and alliances structure knowledge exchange and technological development. Together, these contributions establish innovation as an interactive and institutionally embedded process in which knowledge is generated and exchanged across organizational boundaries, rather than exclusively within individual firms (Freeman, 1995; Lundvall, 1992; Powell et al., 1996; von Hippel, 1988).

2.1.2. Product innovation and degrees of novelty

Building on the conceptual foundations outlined in the previous subsection, innovation can also be differentiated along distinct analytical dimensions, reflecting both its functional orientation and the nature of the underlying knowledge change. A widely used distinction differentiates between product innovation and business process innovation, reflecting different objectives and mechanisms within firms (OECD/Eurostat, 2018). This distinction is particularly relevant to the present study because the empirical analysis focuses on product innovation and on differences in the degree of novelty associated with the products introduced. In the fourth edition of the Oslo Manual, earlier categories, such as organizational and marketing innovation, are consolidated into a broader definition of business process innovation. This evolution illustrates how innovation classifications have been progressively refined across successive editions of the Oslo Manual, with a detailed comparison provided in Appendix A, Table A1

Beyond functional classifications, innovation can also be distinguished according to the nature and extent of the underlying knowledge change. Henderson and Clark (1990), for

example, differentiate incremental, modular, architectural and radical innovation according to changes in core concepts and in the linkages between components. This framework, summarized in Appendix A, Figure A1, illustrates that innovation differs not only in its functional form but also in the extent to which it departs from existing knowledge and technological configurations.

A related distinction concerns the degree of product novelty relative to the market. The Oslo Manual recognizes that novelty may be assessed against different reference points, while the CIS distinguishes product innovations that are new to the market from those that do not reach that level of market novelty (OECD/Eurostat, 2018). This distinction is analytically relevant because introducing a product innovation and introducing one that competitors have not previously offered represent different innovation outcomes. It also allows firms to be characterized through complementary product-innovation profiles according to whether they report neither, one, or both of the categories captured by the survey.

If innovation is both knowledge-based and interactive, and if firms differ in the novelty of the outcomes they achieve, the next question is how they access and organize knowledge that lies beyond their own organizational boundaries.

2.2. From closed to open innovation (OI)

2.2.1. The closed innovation model and its limitations

Traditionally, innovation within firms was predominantly organized according to a closed and internally oriented model, in which research and development activities were largely conducted in-house and closely integrated within firm boundaries, as illustrated by the "knowledge landscape in closed innovation" presented in Appendix B, Figure B1 (Chesbrough, 2003, p. 31). This view is consistent with earlier theoretical perspectives that conceptualized the firm as a central locus of knowledge creation and accumulation, where innovation was primarily driven by internally developed capabilities and routines (Nelson & Winter, 1982; Penrose, 1959). Under this model, firms assumed that successful innovation required internal discovery, development, and commercialization of new ideas, alongside strong control over intellectual property, reflecting the importance attributed to appropriability and complementary assets in capturing returns from innovation (Teece, 1986). In this sense, the closed innovation model represented a dominant and coherent approach to managing innovation within firms, rather than an inherent conceptual limitation (Chesbrough, 2003).

Over time, the assumptions underlying the closed innovation model became increasingly difficult to sustain. As argued by Chesbrough (2003), firms could no longer rely exclusively on internally generated knowledge to sustain innovation performance, as valuable ideas and technologies became more widely distributed beyond organizational boundaries. Earlier contributions had already emphasized that internal R&D plays a dual role, not only in generating new knowledge but also in enabling firms to identify and absorb relevant developments originating outside their boundaries (Cohen & Levinthal, 1990). Increased mobility of skilled researchers and the growing relevance of external actors further weakened firms' ability to maintain exclusive control over critical knowledge assets. Under these conditions, strictly closed approaches to innovation constrained firms' capacity to identify, develop, and commercialize new ideas effectively, revealing the context-dependent limits of the traditional innovation model (Chesbrough, 2003).

Chesbrough (2003) initially defined OI as a model in which firms purposively combine internal and external ideas and pathways to market, explicitly recognizing the strategic relevance of knowledge flows across firm boundaries, and the coexistence of multiple paths to both existing and new markets, as represented in Appendix B, Figure B2. This perspective was later refined to emphasize that such flows are not incidental but deliberately managed through organizational choices involving both inbound and outbound knowledge (Chesbrough et al., 2006). More recently, OI has been conceptualized as a distributed innovation process shaped by purposively managed knowledge flows across organizational boundaries, highlighting its dynamic and evolving nature rather than a fixed set of practices (Chesbrough & Bogers, 2014).

2.2.2. Interorganizational collaboration as a form of openness

Following this perspective, the literature emphasizes that OI is not a uniform or binary phenomenon, but rather varies in both form and intensity (Chesbrough et al., 2006; Laursen & Salter, 2006). In line with this argument, Dahlander and Gann (2010) argue that the concept of openness has been used in multiple and, at times, ambiguous ways in the literature, underscoring the need to distinguish between different forms and degrees of openness rather than treating open innovation as a dichotomous choice. A key distinction concerns the direction of knowledge flows, differentiating between inbound OI, which involves sourcing and integrating external knowledge into internal innovation activities, and outbound OI, whereby firms deliberately externalize internal knowledge through

mechanisms such as licensing or spin-offs (Chesbrough et al., 2006; Dahlander & Gann, 2010). Building on earlier distinctions, Dahlander and Gann (2010) further differentiate between "pecuniary" and "non-pecuniary" forms of openness, distinguishing knowledge flows that involve direct monetary compensation from those that do not. This classification illustrates that external knowledge flows may differ in the mechanisms through which they are accessed or exploited (for further detail see Appendix C, Table C1). These distinctions describe the broader OI paradigm and should not, however, be treated as equivalent to the cooperation construct used in the present empirical analysis.

Building on this understanding of OI as a set of deliberate organizational choices, West and Bogers (2014) argue that openness is enacted through specific mechanisms that govern how firms obtain, integrate, and commercialize external knowledge. Rather than occurring automatically, external knowledge sourcing relies on structured arrangements such as collaborations, alliances, and contractual acquisition, which shape firms' access to external ideas and technologies.

Interorganizational cooperation represents one such route, but it does not capture the full range of practices included under OI. This distinction is particularly important in the present study. The empirical analysis focuses specifically on innovation cooperation, as observed in the CIS, rather than attempting to operationalize OI as a whole. In CIS 2018 and CIS 2020, cooperation is defined around active participation with other enterprises or organizations and explicitly excludes pure contracting-out of work when no active cooperation is involved. CIS 2022 similarly defines cooperation through shared responsibility for tasks and the exchange of information between participants. Across the survey waves, cooperation on R&D and on other innovation activities is therefore conceptually distinct from the simple acquisition of external services or R&D, while the questionnaires do not classify these cooperative relationships as pecuniary or non-pecuniary (European Commission & Eurostat, n.d., 2018, 2022).

Accordingly, interorganizational cooperation is treated in this study as an observable collaborative form of external engagement within the broader OI framework. This narrower focus preserves the conceptual link with OI while avoiding the assumption that the CIS cooperation variables capture all possible inbound, outbound or governance modes of openness.

2.2.3. Participation and breadth of collaboration

Beyond this directional distinction, openness also differs in degree. In this regard, Laursen and Salter (2006) conceptualize openness in terms of the breadth and depth of firms' external knowledge search, highlighting that firms engage with external sources in markedly different ways. From a complementary perspective, Dahlander and Gann (2010) emphasize that openness should be understood as a continuum, whereby firms may selectively open certain stages of the innovation process while keeping others relatively closed, reflecting strategic choices rather than uniform practices.

The breadth of innovation cooperation examined in this study is not identical to the external-search breadth developed by Laursen and Salter (2006). Their measure concerns the range of external knowledge sources used by firms, whereas the CIS cooperation module identifies the types and geographical locations of partners involved in innovation cooperation. The two constructs nevertheless share an important conceptual feature: external engagement varies not only in whether it occurs, but also in its scope. Evidence that cooperation strategies differ according to the type of partner further supports the relevance of distinguishing heterogeneous patterns of collaborative engagement (Belderbos et al., 2004).

Interorganizational collaboration can therefore be approached through two related dimensions. The first is participation in innovation cooperation: whether an enterprise cooperates with external organizations on R&D or other innovation activities. The second is collaboration breadth, reflecting how widely those cooperative relationships extend across the partner types and locations recorded by the CIS. Participation captures the presence of active cooperation, whereas breadth provides additional information on the scope of the reported collaboration network (European Commission & Eurostat, n.d., 2018, 2022).

Within the CIS operationalization used in this study, collaboration breadth is observed only in conjunction with participation in innovation cooperation. Cooperating firms may nevertheless differ considerably in the range of partner types and locations they report. Participation and breadth are therefore complementary rather than independent dimensions of the empirical collaboration profile. This distinction provides a more differentiated account of interorganizational collaboration than a simple open-versus-closed classification. The potential benefits and limitations associated with broader external engagement are considered in the following section.

2.2.4. Trade-offs of open innovation

Chesbrough et al. (2006) also caution that OI involves inherent trade-offs, as increased openness may generate both benefits and managerial challenges. While external collaboration can enhance access to complementary knowledge, it may simultaneously increase coordination costs and organizational complexity (Chesbrough et al., 2006). Empirical evidence shows that the cost-increasing effects of openness can offset its expected benefits, leading to heterogeneous performance outcomes across firms (Faems et al., 2010). This heterogeneity is associated with the organizational and coordination costs inherent in managing portfolios of external collaborations, as captured in the conceptual framework proposed by Faems et al. (2010) and reproduced in Appendix C, Figure C1.

Complementing this view, Dahlander and Gann (2010) argue that the literature on open innovation has traditionally emphasized the benefits of openness, while devoting comparatively less attention to the costs and risks associated with different forms of external knowledge exchange. Drawing on a distinction between inbound and outbound openness, as well as between pecuniary and non-pecuniary modes of exchange, they highlight that each form of openness entails specific advantages and disadvantages that shape firms' openness decisions. As summarized in Table C1, non-pecuniary forms of openness are generally associated with indirect benefits that stem from increased interaction with external actors, such as enhanced learning opportunities and broader exposure to diverse sources of knowledge. However, the absence of formal appropriation mechanisms often makes it difficult for firms to fully capture the value generated through such openness, while simultaneously increasing the risk of unintended knowledge spillovers (Henkel, 2006; Laursen & Salter, 2014). By contrast, pecuniary forms of openness are more directly oriented toward value capture, as market-based exchanges enable firms to access complementary resources and commercialization capabilities, typically through contractual arrangements. At the same time, these forms of openness may create additional governance and coordination requirements, particularly when firms rely extensively on external actors for activities that are strategically relevant (Ahuja, 2000; Lichtenthaler & Ernst, 2007; Powell et al., 1996).

Consistent with the preceding discussion, Dahlander and Gann (2010) emphasize that openness should not be evaluated in aggregate terms, as the costs and benefits associated with openness vary systematically across different openness configurations. In line with this argument, the evidence summarized in Table C1 suggests that increasing openness may generate attention problems, difficulties in partner management, and risks of strategic

misalignment when firms engage with a large number of external actors (Ahuja, 2000; Laursen & Salter, 2006). These challenges reinforce the view that openness introduces organizational frictions that can erode innovation outcomes if not carefully managed.

This section suggests that open innovation cannot be treated as a universally value-enhancing strategy, but rather as an organizational choice whose outcomes depend on how openness is managed (Chesbrough et al., 2006; Dahlander & Gann, 2010; Faems et al., 2010). Collectively, these insights indicate that access to external knowledge alone is insufficient to explain innovation outcomes, directing attention to firms' internal ability to recognize, assimilate, and exploit externally sourced knowledge. In this context, absorptive capacity emerges as a central mechanism through which openness translates into innovation outcomes, explaining why firms differ in their ability to benefit from interorganizational collaboration (Cohen & Levinthal, 1990).

2.3. Absorptive capacity and interorganizational collaboration

2.3.1. Absorptive capacity: concept and dynamic capability

Cohen and Levinthal (1990) introduced the concept of absorptive capacity to explain why firms differ in their ability to benefit from knowledge developed outside their boundaries. They define absorptive capacity as a firm's ability to recognize the value of new external information, assimilate it, and apply it to commercial ends. This perspective underscores that access to external sources of knowledge, by itself, is insufficient to foster innovation. Instead, firms must possess internal learning capabilities that enable them to identify relevant external inputs and integrate them effectively with existing knowledge bases (Cohen & Levinthal, 1990). Absorptive capacity thus provides a foundational explanation for firm-level differences in the ability to benefit from external knowledge.

Subsequent contributions have extended the original formulation of absorptive capacity by emphasizing its dynamic and process-based nature. In a highly influential contribution, Zahra and George (2002) define absorptive capacity (ACAP) as a dynamic capability composed of interrelated organizational processes, distinguishing between potential absorptive capacity (PACAP), which reflects a firm's ability to acquire and assimilate external knowledge, and realized absorptive capacity (RACAP), which concerns the transformation and exploitation of that knowledge for commercial purposes (Appendix D, Figure D1). At the same time, critical reassessments of the absorptive capacity literature have highlighted the need for conceptual clarity, stressing that absorptive capacity should be understood as a

multidimensional and context-dependent construct rather than a static stock of knowledge (Lane et al., 2006). Together, these perspectives reinforce the view that absorptive capacity evolves through organizational learning processes and plays a central role in shaping how firms leverage external knowledge over time (Lane et al., 2006; Zahra & George, 2002).

2.3.2. Absorptive capacity and collaboration outcomes

Intraorganizational knowledge exchange expands business units' access to diverse and complementary knowledge, but its innovation benefits depend on absorptive capacity, which conditions the ability to absorb and exploit knowledge sourced from other units within the firm (Tsai, 2001). At the interorganizational level, Lane and Lubatkin (1998) argue that learning between firms depends on relative absorptive capacity, highlighting that similarities in knowledge bases and learning processes condition the extent to which partners can effectively learn from one another. This relational view underscores that collaboration outcomes may depend on the characteristics and knowledge bases of the firms involved.

More broadly, the literature emphasizes that absorptive capacity helps explain why firms differ in their ability to derive innovation benefits from external knowledge, while also being shaped by organizational and contextual factors (Volberda et al., 2010). Collaboration may therefore provide access to knowledge and capabilities located outside the firm, but differences in internal knowledge bases and learning capabilities can help explain why comparable forms of external engagement are associated with different innovation outcomes across firms (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Volberda et al., 2010).

In the present study, absorptive capacity is used as a theoretical lens rather than tested as a mediating mechanism. The empirical specification controls for external R&D contracting and the share of employees with tertiary education, which capture selected aspects of firms' access to external research inputs and internal human capital, respectively. These variables do not constitute direct measures of absorptive capacity, but their inclusion helps account for observable differences in knowledge-related resources that may be associated with firms' capacity to benefit from collaboration.

Taken together, the open-innovation and absorptive-capacity perspectives suggest that the relationship between interorganizational collaboration and innovation cannot be understood solely in terms of access to external partners. It must also be considered in relation to the knowledge resources available within the firm. This provides the theoretical

basis for examining whether participation in innovation cooperation and the breadth of collaborative engagement are associated with different innovation-related outcomes.

2.4. Interorganizational collaboration and innovation-related outcomes

2.4.1. Market novelty and product innovation

A central question, therefore, is whether interorganizational collaboration is associated not only with the occurrence of innovation, but also with the novelty of the products firms introduce.

As discussed in Section 2.1.2, product innovations differ in their degree of novelty. The Oslo Manual distinguishes novelty according to the reference point against which an innovation is assessed, including whether a product is new to the firm or reaches a higher level of novelty relative to the market (OECD/Eurostat, 2018). Market novelty is particularly relevant in this context because it indicates that a firm has introduced a product not previously available in the market it serves. This market-based notion should not be equated with radical innovation in a technological sense, but it provides a meaningful distinction between different product-innovation outcomes (OECD/Eurostat, 2018).

External engagement can broaden the range of knowledge sources available to firms, creating additional opportunities for innovation (Laursen & Salter, 2006; Leiponen & Helfat, 2010). Laursen and Salter (2006) show that firms differ substantially in the breadth and depth of their external knowledge search and relate these dimensions to innovation performance, while also demonstrating that the benefits of increasing openness are not unlimited. Similarly, Leiponen and Helfat (2010) emphasize the potential value of drawing on a broader range of knowledge sources when pursuing innovation, as wider search horizons can increase the opportunities available for identifying and combining relevant knowledge. Cooperation strategies also differ across partner types, reinforcing the view that external engagement is heterogeneous rather than uniform (Belderbos et al., 2004).

Interorganizational collaboration may therefore be associated with product innovation through access to complementary and heterogeneous knowledge, while broader collaborative engagement may increase the variety of external inputs available to firms (Laursen & Salter, 2006; Leiponen & Helfat, 2010). However, as the preceding sections have shown, these potential benefits are neither automatic nor unlimited (Laursen & Salter, 2006). The

relationship between collaboration and market novelty consequently remains an empirical question rather than an inherent consequence of openness.

2.4.2. The strategic importance of innovation

The relevance of innovation to firms extends beyond realized innovation outputs. Innovation can also occupy different positions within firms' strategic priorities. Siguaw et al. (2006) conceptualize innovation orientation as a multidimensional organizational knowledge structure that includes a strategic direction guiding organizational strategies and actions towards innovation. The strategic importance assigned to innovation should nevertheless be distinguished from realized business performance. Venkatraman and Ramanujam (1986) conceptualize business performance as a multidimensional outcome encompassing financial and broader operational criteria. In the present context, the importance assigned to introducing new goods or services therefore reflects a narrower aspect of firms' strategic emphasis on innovation rather than the performance ultimately achieved.

This distinction is particularly relevant in the context of OI. Chesbrough and Appleyard (2007) argue that openness has implications for strategy because firms must reconcile the use of distributed knowledge and external participation with decisions concerning value creation and value capture. External engagement is therefore not simply a means of acquiring additional technological inputs; it can form part of the way firms organize their innovation activities and pursue strategic objectives. The growing importance of external actors consequently challenges strategy perspectives based exclusively on internal ownership and control of knowledge (Chesbrough & Appleyard, 2007).

West and Bogers (2014) similarly emphasize that leveraging external sources of innovation involves processes through which firms obtain, integrate, and commercialize externally sourced knowledge. External engagement can therefore form part of how firms organize their innovation activities, although this does not establish that more collaborative firms necessarily attribute greater strategic importance to innovation. Rather, these perspectives provide a conceptual basis for examining whether participation in innovation cooperation and collaboration breadth are associated with the importance firms assign to introducing new goods or services. Such an association should not be interpreted as evidence of superior firm performance.

Market novelty and the strategic importance attributed to innovation therefore capture complementary dimensions: the former concerns a realized product-innovation outcome,

whereas the latter reflects the strategic relevance assigned to the introduction of new goods or services.

2.4.3. Product-innovation profiles

Product innovation can also be examined beyond a single distinction between innovative and non-innovative firms. The Oslo Manual emphasizes that innovation status alone provides limited information about differences between firms and recommends combining information on innovation with characteristics such as the degree of novelty to construct more informative innovation profiles (OECD/Eurostat, 2018). Product innovations may therefore be differentiated according to their position relative to the firm's previous offerings and to those already available in the market.

Considering product-innovation categories jointly provides a complementary way of characterizing firms according to the composition of their reported innovation activity. Such an approach preserves information on differences in product novelty that would be lost by reducing innovation to a single binary indicator (OECD/Eurostat, 2018). These profiles should not necessarily be interpreted as an ordered hierarchy of innovation performance, but rather as different configurations of reported product-innovation activity.

Given the heterogeneity of collaborative engagement documented in the literature (Belderbos et al., 2004; Laursen & Salter, 2006), it is relevant to examine whether its association with product innovation differs across configurations of reported innovation activity. Examining these profiles therefore complements the specific focus on market novelty and provides a broader perspective on the relationship between interorganizational collaboration and product innovation.

Overall, the literature suggests that the relationship between interorganizational collaboration and innovation cannot be adequately represented by a single innovation-related outcome. Market novelty captures a realized dimension of product innovation, the importance assigned to introducing new goods or services reflects its strategic relevance to the firm, and product-innovation profiles preserve differences in the composition of reported innovation activity. These complementary perspectives provide the conceptual basis for examining the associations of participation in innovation cooperation and collaboration breadth with different innovation-related outcomes. The following section reviews the empirical evidence on these relationships, first internationally and then in the Portuguese context.

2.5. Empirical evidence on OI and innovation-related outcomes

2.5.1. General empirical patterns

Empirical research generally associates external knowledge engagement with innovation, while also showing that this relationship depends on how openness is organized. Using data on UK manufacturing firms, Laursen and Salter (2006) find that the breadth and depth of external knowledge search are related to innovation performance, but that the benefits of openness are subject to diminishing returns (see Appendix E, Figures E1 and E2). Their results point to an inverted U-shaped relationship, suggesting that extending the range or intensity of external search may become less beneficial beyond a certain level (see Appendix E, Figure E1). The value of breadth may also depend on firms' previous experience. Love et al. (2014) find that firms with substantial prior experience of external innovation linkages obtain greater innovation returns from current linkage breadth, indicating that organizations can learn over time how to manage external relationships more effectively.

A broader assessment of this literature points in the same direction while highlighting considerable heterogeneity. Xie et al. (2023), in a meta-analysis covering 50 independent empirical samples, find an overall positive association between collaborative innovation and innovation performance. They also show that formal and informal institutional conditions moderate this relationship. This suggests that the outcomes associated with collaborative innovation depend partly on the institutional context in which collaboration takes place.

Partner configuration represents another source of heterogeneity. Belderbos et al. (2004) distinguish cooperation with competitors, suppliers, customers, and universities or research institutions and show that the determinants of cooperation differ substantially across partner types. External collaboration should therefore not be treated as a homogeneous organizational practice, since firms may engage with different external actors for different reasons and under different conditions.

The outcomes of OI are consequently not uniformly positive. Cheng and Huizingh (2014) report positive relationships between OI activities and several dimensions of innovation performance, while also showing that these relationships vary with firms' strategic orientations. In contrast, Knudsen and Mortensen (2011) identify adverse immediate effects of greater openness on new-product-development performance, including longer development times and higher costs. Research on technology alliance portfolios similarly

identifies both value-enhancing and cost-increasing effects, while evidence from SMEs shows that organizational and strategic context influences how external engagement translates into innovation performance (Crema et al., 2014; Faems et al., 2010).

The type of innovation outcome considered provides a further source of variation. Ebersberger et al. (2021), examining the robustness of previous evidence on inbound OI across innovation survey data from France, Germany, and the United Kingdom, find that explanations of new-to-the-firm innovation are generally more robust than those of new-to-the-world innovation. Their results indicate that conclusions about openness may depend partly on how innovation performance and novelty are defined, reinforcing the importance of distinguishing between different innovation-related outcomes.

Taken together, the international evidence supports an association between external engagement and innovation, but not a single or universal performance effect. The observed relationships vary with the breadth of external engagement, prior collaborative experience, partner configuration, strategic and institutional context, and the outcome under consideration. Recent assessments of the OI literature similarly emphasize that important questions remain concerning the measurement and empirical identification of these relationships (Laursen & Salter, 2023). The evidence therefore supports a differentiated view of interorganizational collaboration in which participation, scope, and innovation outcomes need not move together.

2.5.2. Empirical evidence from the Portuguese context

Evidence from Portugal has developed more gradually and likewise points to a heterogeneous picture. Early firm-level research by Teixeira and Lopes (2012), based on a sample of 70 innovative Portuguese firms, found that firms tended to adopt a relatively more closed innovation model than firms operating in economies closer to the technological frontier. External knowledge absorption was considerably more widespread than outward knowledge transfer, suggesting a stronger emphasis on accessing external knowledge than on actively externalizing internally developed knowledge. These findings should nevertheless be interpreted within the scope and period of the study rather than as a general characterization of the population of Portuguese firms.

Later research provides a more differentiated picture of external engagement. Using CIS 2012 data, Fernandes et al. (2017) find that innovation among Portuguese enterprises remained predominantly firm-based rather than cooperation-based, particularly in relation to

the introduction of new products, while also documenting substantial differences across sectors and external sources of cooperation. From a broader networking perspective, Nunes et al. (2019) find that more intensive engagement in knowledge networks is associated with a greater likelihood of higher innovation levels and highlight the complementary role of informal interaction alongside formal networks. Cesário and Fernandes (2019), using CIS 2014 data on Portuguese SMEs, further examine the relationship between a smart-open innovation approach and innovation performance, emphasizing the relevance of the geographical scale and range of actors involved in firms' networking strategies. Together, these studies indicate that external engagement is relevant to Portuguese innovation, but also that its role varies with the structure and configuration of firms' external relationships.

Research focused on SMEs further illustrates this diversity. Almeida (2021), based on a sample of 187 Portuguese SMEs, finds that outside-in practices are more prevalent than inside-out practices, with suppliers and customers representing particularly important external knowledge sources. The study also identifies resource limitations and difficulties in integrating external knowledge among the challenges associated with implementing OI. More recent evidence extends this implementation perspective. Using a sample of 297 Portuguese SMEs, Almeida (2024) identifies several sources of failure in OI practices, with resource constraints and the management of open-innovation processes playing an important role. Together, these findings suggest that access to external knowledge alone does not ensure that firms are able to organize and exploit it effectively.

Sector-specific evidence further illustrates this heterogeneity. Using CIS 2020 data for 505 tourism-related firms, Ademuyiwa et al. (2025) report that innovation in the Portuguese tourism sector remains more frequently firm-based than cooperation-based and that process innovation is more prevalent than product innovation. Given the sector-specific population examined, however, these findings should not be generalized automatically to the Portuguese business economy as a whole.

Institutional evidence provides a complementary, although conceptually distinct, perspective. In the specific context of FDI–SME linkages, the OECD (2022) examines how Portuguese SMEs can benefit from knowledge and technology spillovers transmitted through value-chain relationships, strategic partnerships, labor mobility, and other interactions with foreign firms. The report emphasizes that the benefits associated with such external linkages also depend on domestic firms' capacity to absorb the knowledge to which they are exposed. This evidence is therefore informative about the broader environment for

inter-firm knowledge diffusion, although it should not be interpreted as a direct measure of OI adoption across Portuguese firms.

The European Innovation Scoreboard 2026 presents a more nuanced national picture. Portugal is classified as a Moderate Innovator, with innovation performance indexed at 93.2% of the EU average and a rank of 15th among Member States. Its aggregate Linkages score stands above the EU benchmark, at 109.6%, while the more specific indicator for innovative SMEs collaborating with others remains below it, at 87.6%. The aggregate Linkages dimension also incorporates public-private co-publications and job-to-job mobility of HRST and should therefore not be interpreted as a direct measure of firm-level innovation cooperation (see Appendix F, Table F1). At the same time, the latter indicator has improved relative to 2019 (see Appendix F, Figure F2). Portugal also performs strongly in sales of new-to-market and new-to-firm innovations, at 133% of the EU benchmark and fourth among Member States. These contrasts are summarized in Appendix F, Figure F1. The underlying 2022 innovation profile shows a similar contrast: in-house product innovators with market novelties represent 11.0% in Portugal compared with 5.1% in the EU27, while the corresponding shares for product innovators without market novelties are 13.4% and 5.9%, respectively (European Commission, 2026). These differences are illustrated in Appendix F, Figure F3.

These indicators caution against describing the Portuguese innovation system simply as either open or closed. Relatively strong product-innovation indicators coexist with a more uneven position across measures of collaborative engagement, while the latter have themselves evolved over time. This is consistent with the firm-level literature, which documents different patterns of openness according to period, firm population, sector, partner configuration, and form of external engagement.

Overall, the Portuguese evidence remains dispersed across different periods, samples, sectors, and definitions of openness. Earlier studies identify a comparatively strong role for internally driven innovation and outside-in knowledge flows, while subsequent research documents relevant but heterogeneous patterns of networking and interorganizational engagement (Ademuyiwa et al., 2025; Almeida, 2021, 2024; Cesário & Fernandes, 2019; Fernandes et al., 2017; Nunes et al., 2019; Teixeira & Lopes, 2012). Recent institutional evidence adds a more current national perspective but does not remove this heterogeneity (European Commission, 2026; OECD, 2022). The reviewed literature therefore provides limited recent economy-wide firm-level evidence that jointly examines participation in

innovation cooperation, the scope of collaborative engagement, and their associations with different innovation-related outcomes in Portugal. This leaves room for a more integrated assessment based on recent firm-level evidence.

Table 2.1. From innovation theory to the empirical framework: literature synthesis

Stage	What the literature establishes	Key references	Implication for this study
1. Innovation foundations and novelty	Innovation is a cumulative, interactive and knowledge-based process embedded in technological and institutional contexts. Product innovation also differs in degree of novelty.	Schumpeter (1934); Kline & Rosenberg (1986); Lundvall (1992); Freeman (1995); OECD/Eurostat (2018)	Supports distinguishing market novelty and complementary product-innovation profiles rather than treating innovation as a single outcome.
2. OI and collaboration	OI concerns purposively managed knowledge flows across organizational boundaries. Innovation cooperation is one observable form of this broader paradigm, and external engagement differs in participation, scope and partner configuration.	Chesbrough (2003); Dahlander & Gann (2010); West & Bogers (2014); Laursen & Salter (2006); Belderbos et al. (2004)	Motivates the joint use of cooperation participation and collaboration breadth as complementary dimensions of firms' collaboration profiles.
3. Benefits are conditional	External engagement can expand access to complementary knowledge, but may also create coordination costs, attention problems and diminishing returns. Firms differ in their ability to absorb and exploit external knowledge.	Cohen & Levinthal (1990); Zahra & George (2002); Laursen & Salter (2006); Faems et al. (2010)	Supports a differentiated interpretation: positive average associations are plausible, but collaboration is neither sufficient nor universally beneficial.
4. Outcomes and empirical heterogeneity	International evidence is generally positive but varies across contexts, collaboration configurations and outcome definitions. Strategic importance should also be distinguished from realized innovation and business performance.	Siguaw et al. (2006); Venkatraman & Ramanujam (1986); Ebersberger et al. (2021); Xie et al. (2023)	Justifies examining three distinct outcomes: market novelty, strategic importance of innovation and product-innovation profiles.
5. Portuguese evidence and research gap	Portuguese evidence documents relevant external engagement but remains dispersed across periods, sectors, firm populations and definitions of openness; recent institutional indicators likewise show an uneven collaboration profile.	Teixeira & Lopes (2012); Fernandes et al. (2017); Nunes et al. (2019); Cesário & Fernandes (2019); Almeida (2021, 2024); European Commission (2026)	Leaves limited recent economy-wide firm-level evidence jointly assessing cooperation participation, collaboration breadth and multiple innovation-related outcomes in Portugal.

Note. Representative references are shown to summarize the cumulative argument developed in Sections 2.1–2.5; the table is not an exhaustive inventory of the literature reviewed.

3. Empirical Methodology

This chapter describes the empirical design used to examine how interorganizational collaboration is associated with innovation-related outcomes among Portuguese enterprises covered by the CIS. The analysis combines three waves of the Community Innovation Survey (CIS) in a common firm-level framework and estimates three econometric models corresponding to the three innovation-related outcomes.

3.1. Research question and hypotheses

The literature reviewed in the previous sections establishes interorganizational collaboration as an important channel through which firms can access knowledge, capabilities and resources located beyond their organizational boundaries. At the same time, it does not support a simple relationship in which greater openness necessarily produces superior innovation outcomes. The benefits associated with external engagement depend on how collaboration is organized, the breadth and configuration of external relationships, firms' ability to absorb external knowledge, and the particular innovation outcome considered (Cohen & Levinthal, 1990; Ebersberger et al., 2021; Laursen & Salter, 2006; Love et al., 2014; Xie et al., 2023). This heterogeneity makes it important to distinguish different dimensions of collaborative engagement rather than treating openness as a single firm characteristic.

The Portuguese evidence points to a similar conclusion. Existing studies show that external knowledge and cooperation are relevant to innovation among Portuguese firms, but the available evidence is dispersed across different periods, sectors, firm populations and operationalizations of openness (Ademuyiwa et al., 2025; Almeida, 2021, 2024; Cesário & Fernandes, 2019; Fernandes et al., 2017; Nunes et al., 2019; Teixeira & Lopes, 2012). Several of these studies focus on particular sectors or SMEs, while the constructs used to represent external engagement also vary between studies. Recent institutional indicators provide a broader picture of the Portuguese innovation system, but they do not substitute for firm-level evidence on how participation in innovation cooperation and the scope of collaborative engagement relate to different innovation outcomes.

The reviewed evidence therefore points to two closely related gaps. First, there is limited recent firm-level evidence covering a broad range of economic activities in Portugal that examines participation in innovation cooperation and collaboration breadth within the same empirical framework. This distinction is relevant because participation captures whether

active innovation cooperation occurs, whereas breadth provides additional information on how widely cooperative relationships extend across partner types and geographical locations. Although the two dimensions are necessarily related, they describe different features of firms' collaboration profiles and should therefore not be treated as interchangeable.

Second, the relationship between collaboration and innovation cannot be adequately represented through a single outcome. Market novelty captures a realized dimension of product innovation; the importance attributed to introducing new goods or services reflects the strategic position assigned to innovation within the firm; and product-innovation profiles preserve differences in the composition of reported innovation activity. Evidence that the relationship between openness and innovation varies according to how innovation outcomes are defined further supports examining these dimensions separately rather than relying on a single broad measure of performance (Ebersberger et al., 2021).

The resulting research question is therefore more specific than a general assessment of whether OI improves firm performance:

To what extent are participation in innovation cooperation and collaboration breadth associated with different innovation-related outcomes among Portuguese enterprises covered by the CIS?

The study contributes to the existing evidence in three related ways. It provides recent firm-level evidence covering a broad range of economic activities in Portugal using the harmonized CIS 2018, 2020 and 2022 waves; it distinguishes the occurrence of innovation cooperation from the scope of the reported collaboration network; and it examines whether the resulting associations extend across complementary dimensions of innovation behavior rather than relying on a single outcome.

The theoretical basis for expecting an association between collaboration and innovation follows from the role of external knowledge in the innovation process. OI recognizes that relevant knowledge is distributed across organizational boundaries and that firms may complement their internal resources through relationships with external actors (Chesbrough, 2003; West & Bogers, 2014). Such relationships can expose firms to technological knowledge, market information and complementary capabilities that would otherwise be more difficult to access internally. Their effective use nevertheless depends on firms' capacity to recognize, assimilate and exploit external knowledge, which helps explain why similar forms of collaboration need not generate identical outcomes across firms (Cohen & Levinthal, 1990).

Participation in innovation cooperation provides one observable manifestation of this external engagement. Cooperation involves active interaction rather than the simple purchase of an external input and can facilitate the exchange and combination of knowledge between firms and other organizations. Empirical research generally reports a positive association between collaborative innovation and innovation performance, although the magnitude of this relationship varies across institutional and organizational settings (Xie et al., 2023). Evidence on Portuguese firms similarly indicates that cooperation and wider knowledge networks can play a relevant role in innovation, while also showing substantial heterogeneity across firms, sectors and collaboration configurations (Cesário & Fernandes, 2019; Fernandes et al., 2017; Nunes et al., 2019).

These arguments suggest that firms participating in innovation cooperation should be more likely to report innovation-related outcomes that reflect both realized product innovation and a stronger strategic emphasis on innovation. These arguments motivate the expectation of a positive association between participation in innovation cooperation and the innovation-related outcomes considered.

H1a. Participation in innovation cooperation is positively associated with the probability of introducing market-new product innovations.

H1b. Participation in innovation cooperation is positively associated with greater strategic importance attributed to introducing new goods or services.

H1c. Participation in innovation cooperation is associated with a higher probability of reporting exactly one or both product-innovation categories relative to neither category.

The presence of cooperation alone, however, does not describe the scope of firms' external relationships. Firms may collaborate with a narrow set of actors or engage across multiple partner types and geographical locations. Research on external search shows that broader engagement can increase the variety of knowledge and technological alternatives available to firms, thereby creating additional opportunities for identifying and combining information relevant to innovation (Laursen & Salter, 2006; Leiponen & Helfat, 2010). Previous collaborative experience may also improve firms' ability to benefit from broader external linkages over time (Love et al., 2014).

The literature simultaneously cautions that breadth is not unconditionally beneficial. Expanding external engagement can increase search, coordination and managerial costs, and Laursen and Salter (2006) show that the benefits of external search may eventually exhibit

diminishing returns. The cooperation-breadth measure used in this study is not identical to their external-search measure, and the empirical specification does not test a nonlinear optimum. The hypothesis therefore concerns the average association between the reported scope of innovation cooperation and the outcomes considered, rather than implying that progressively greater breadth is always beneficial.

Because collaboration breadth is observed as part of the same cooperation profile, it should also be understood as complementary to participation rather than as an independent form of openness. Within this complementary view of the collaboration profile, greater breadth is expected to be positively associated with the innovation-related outcomes considered.

H2a. Greater collaboration breadth is positively associated with the probability of introducing market-new product innovations.

H2b. Greater collaboration breadth is positively associated with greater strategic importance attributed to introducing new goods or services.

H2c. Greater collaboration breadth is associated with a higher probability of reporting exactly one or both product-innovation categories relative to neither category.

The two sets of hypotheses are examined across three complementary outcomes, with H1 concerning participation in innovation cooperation and H2 collaboration breadth. They neither imply an ordering of product-innovation profiles nor treat the three outcomes as measures of a common latent construct. Instead, the analysis assesses whether the expected associations with each collaboration dimension hold across market novelty, strategic orientation towards innovation, and the composition of reported product-innovation activity.

Table 3.1. Summary of the hypotheses

Innovation-related outcome	Participation in innovation cooperation	Collaboration breadth
Market-new product innovation	H1a. Positive association	H2a. Positive association
Strategic importance of introducing new goods or services	H1b. Positive association	H2b. Positive association
Product-innovation profile	H1c. Higher probability of exactly one or both vs. neither	H2c. Higher probability of exactly one or both vs. neither

Note. H1a–H1c concern participation in innovation cooperation; H2a–H2c concern collaboration breadth. The two dimensions are modeled jointly as complementary features of the collaboration profile. The theoretical reasoning underlying the hypotheses is developed in this section.

3.2. Data description

3.2.1. CIS, research design and analytical sample

The study uses firm-level microdata from the Portuguese CIS 2018, CIS 2020 and CIS 2022, covering the reference periods 2016–2018, 2018–2020 and 2020–2022, respectively. These waves follow the innovation framework introduced by the fourth edition of the Oslo Manual and provide a sufficiently consistent basis for comparing the constructs used in this study (Eurostat, 2020, 2022, 2024; OECD/Eurostat, 2018).

The three waves are pooled as repeated cross-sections: each observation represents an enterprise in one CIS wave, but firms cannot be reliably followed through time. The data are therefore not treated as a firm-level panel (Wooldridge, 2010).

The CIS is a biennial enterprise survey that collects harmonized information on innovation activities and related organizational characteristics. In Portugal, the enterprise is the statistical unit and the target population covers enterprises with at least 10 persons employed across the survey's eligible economic activities. The sampling frame is stratified by economic activity, employment size and NUTS II region, with size classes of 10–49, 50–249 and 250 or more persons employed (Eurostat, 2020, 2022, 2024).

The empirical analysis uses the anonymized scientific-use records available for the Portuguese CIS 2018, 2020 and 2022. The wave-specific scientific-use datasets used in the analysis contain 13,701, 13,509 and 13,802 observations, respectively. No observations were excluded when constructing the main analytical sample.

The wave-specific datasets were harmonized with respect to variable coding and questionnaire routing and subsequently appended, yielding a pooled dataset of 41,012 enterprise-wave observations. Following the harmonization and structural recodings described in Section 3.2.2, all 41,012 observations contain non-missing values for the variables required in Models A1–A3 and therefore enter the common pooled estimation sample. Survey weights are not applied in the final specifications; accordingly, the estimates are not presented as population-representative estimates for Portuguese firms.

Table 3.2. CIS waves and observations

Survey wave	Reference period	Observations
CIS 2018	2016–2018	13,701
CIS 2020	2018–2020	13,509
CIS 2022	2020–2022	13,802
Total	—	41,012

Note. Record counts refer to the final harmonized scientific-use files used in Stata, not to weighted estimates of the enterprise population. Survey reference periods follow Eurostat (2020, 2022, 2024).

3.2.2. Data harmonization

Each wave was prepared separately before pooling so that questionnaire routing and variable coding could be checked against the corresponding CIS questionnaire. Variables were harmonized across waves according to their substantive definitions in the respective questionnaires. Economic activity was preserved as a common textual CAE Rev. 3 division identifier and re-encoded only after the three files were appended, ensuring that the same sector label received the same pooled code. The lower level of detail available in CIS 2020 for the combined 02_03 category was retained rather than artificially disaggregated.

Missing values generated by questionnaire routing were recoded only where the survey logic clearly implied the absence of the corresponding characteristic. Firms reporting neither new nor improved goods nor new or improved services were not asked the subsequent product-novelty questions, and the resulting structural missing values were therefore coded as zero. Partner-location items used to construct collaboration breadth were treated analogously when missing values resulted from the routing of the cooperation module (European Commission & Eurostat, n.d., 2018, 2022).

A wave-specific adjustment was required for the enterprise-group variables in CIS 2022. For 2,915 enterprises identified as belonging to a group headquartered in Portugal, the foreign-head-office indicator was structurally missing because the domestic- and foreign-head-office categories are mutually exclusive. These observations were therefore coded as zero on the foreign indicator (European Commission & Eurostat, 2022).

The final Stata do-file reconstructs the analytical variables from the cleaned wave files and applies consistency and missing-data checks before estimation, providing a reproducible record of the data-preparation procedure.

3.3. Variables description

3.3.1. Measures of Innovation

Table 3.3. Measures of innovation

Outcome	Variable	CIS item(s)	Definition
Outcome A1	Market-new product innovation	B0201	Binary: 1 if the enterprise introduced a new or improved product not previously offered by competitors; 0 otherwise.
Outcome A2	Strategic importance of introducing new goods or services	A0102	Ordered scale: 0 not important, 1 low, 2 medium, 3 high.
Outcome A3	Product-innovation profile	B0201 + B0202	Nominal profile: 0 neither CIS product-innovation category, 1 exactly one category, 2 both categories.

Note. Substantive labels are used in the text; CIS item codes are retained for traceability. Variable definitions and routing follow the harmonized CIS questionnaires (European Commission & Eurostat, n.d., 2018, 2022).

Market-new product innovation records whether the enterprise introduced a new or improved product that had not previously been offered by any competitor. It therefore captures novelty relative to the market, consistent with the CIS and Oslo Manual distinction between different degrees of product novelty (Eurostat, 2020, 2022, 2024; OECD/Eurostat, 2018).

Strategic importance of introducing new goods or services measures the importance assigned to this objective for the enterprise's economic performance. The original four categories (none, low, medium and high) are preserved, providing an ordered measure of strategic orientation that is distinct from realized product innovation.

The product-innovation profile combines the two CIS product-novelty indicators. It distinguishes firms reporting neither category, exactly one category, or both categories. The intermediate category is decomposed only for descriptive checking into "market-new only" and the complementary product-innovation category; this auxiliary variable is not used in estimation. Because the three profiles are qualitatively distinct and not assumed to be equally spaced, the final specification treats them as nominal outcomes.

Table 3.4. Distribution of innovation outcomes by CIS wave

Variable / category	CIS 2018	CIS 2020	CIS 2022	All
Market-new product innovation				
No	86.94	85.72	86.43	86.36
Yes	13.06	14.28	13.57	13.64
Strategic importance of introducing new goods or services				
Not important	9.68	8.69	11.74	10.05
Low	12.58	13.47	16.14	14.07
Medium	45.06	42.96	39.65	42.55
High	32.68	34.88	32.47	33.34
Product-innovation profile				
Neither	73.67	71.23	69.09	71.33
Exactly one	16.20	17.37	20.91	18.17
Both	10.13	11.39	10.00	10.50
Observations	**13,701**	**13,509**	**13,802**	**41,012**

Note. Entries are percentages within each CIS wave and in the pooled sample, except for the final row. Percentages are calculated from the common harmonized analytical sample (N = 41,012).

3.3.2. Measures of Cooperation and Controls

Table 3.5. Measures of cooperation and controls

Specification component	Variable	CIS item(s)	Definition
Main explanatory variable	Cooperation for innovation	B1501, B1502	Binary: 1 if the enterprise cooperated on R&D or other innovation activities; 0 if both answers were no.
Main explanatory variable	Collaboration breadth	B1601–B1630	Sum of 30 partner-type/location combinations recorded in the cooperation grid; range 0–30.
Control	External R&D contracting	B0907	Binary indicator of R&D contracted to enterprises or research organizations; external-knowledge proxy.
Control	Share of persons employed with tertiary education	C0100	Seven categories: 0%; 1–<5%; 5–<10%; 10–<25%; 25–<50%; 50–<75%; and ≥75%. Entered as categorical indicators, with 0% as reference.
Control	Group head office in Portugal	C0401	Binary enterprise-group location indicator.
Control	Group head office abroad	C0403	Binary enterprise-group location indicator; independent enterprises are the omitted category when both group indicators equal zero.
Fixed effects	Economic activity	CAE Rev. 3 division	Harmonized pooled sector categories.
Fixed effects	Survey wave	2018, 2020, 2022	Wave indicators; CIS 2018 is the reference category.

Note. Substantive labels are used in the text; CIS item codes are retained for traceability. Variable definitions and routing follow the harmonized CIS questionnaires (European Commission & Eurostat, n.d., 2018, 2022).

Interorganizational collaboration is represented by two related measures. Cooperation for innovation equals one when the enterprise reports cooperation on R&D or on other innovation activities. Collaboration breadth sums the 30 partner-type/location combinations recorded in the cooperation grid. Including both variables distinguishes participation in cooperation from variation in the reported network among cooperating firms. Because breadth is structurally zero for non-cooperators, the two estimates are interpreted jointly as dimensions of the same collaboration profile rather than as independent treatment effects.

Among the controls, external R&D contracting captures access to externally performed R&D, while the share of persons employed with tertiary education captures the firm's internal human-capital base. The latter enters the models as seven categorical indicators, with 0% as the reference category, avoiding a linearity assumption across percentage bands of unequal width. Both variables are related to absorptive capacity but are not treated as direct measures of the construct.

Domestic- and foreign-headed group indicators distinguish group-affiliated enterprises from the reference category of independent firms. CAE Rev. 3 division effects control for systematic sector differences, and CIS-wave effects account for common shifts across the three survey periods.

Table 3.6. Descriptive statistics for cooperation and controls by CIS wave

Variable / category	CIS 2018	CIS 2020	CIS 2022	All
Cooperation for innovation — Yes	9.32	10.44	13.51	11.10
Collaboration breadth — Mean (SD)	0.411 (1.726)	0.472 (1.894)	0.629 (2.192)	0.504 (1.950)
External R&D contracting — Yes	6.30	7.27	8.59	7.39
Share of persons employed with tertiary education				
0%	14.69	14.04	11.61	13.44
1% to <5%	28.63	23.80	22.62	25.02
5% to <10%	12.82	10.96	11.46	11.75
10% to <25%	16.11	14.53	16.12	15.59
25% to <50%	10.68	11.45	11.93	11.35
50% to <75%	8.33	10.70	10.78	9.93
75% or more	8.74	14.52	15.48	12.91
Group head office in Portugal — Yes	19.44	21.04	21.12	20.53
Group head office abroad — Yes	10.58	11.53	12.29	11.46
Observations	**13,701**	**13,509**	**13,802**	**41,012**

Note. Unless otherwise indicated, entries are percentages within each CIS wave and in the pooled sample. Collaboration breadth is reported as mean (standard deviation). Tertiary education is reported by category. All statistics are calculated from the common harmonized analytical sample (N = 41,012).

3.4. Econometric models

All pooled models use the same explanatory variables and controls and include CAE Rev. 3 division effects and CIS-wave effects to account for systematic differences across sectors and common shifts across survey periods, respectively. Let Cooperation_i denote cooperation for innovation, Breadth_i collaboration breadth, X_i the remaining firm-level controls, δ_s sector effects and λ_t CIS-wave effects. The choice of estimator depends on the nature of the dependent variable. Huber–White robust standard errors are reported throughout (Wooldridge, 2010).

3.4.1. Market-new product innovation

Model A1 estimates the probability that an enterprise reports market-new product innovation. Because the dependent variable is binary, the pooled specification is estimated by logit:

$$\log\left(Pr(Y_i = 1) / Pr(Y_i = 0)\right) = a + \beta_1 Cooperation_i + \beta_2 Breadth_i + \gamma' X_i + \delta_s + \lambda_t \qquad (3.1)$$

The coefficients are expressed in log-odds and are therefore not read directly as probability changes. Average marginal effects (AMEs) are used for substantive interpretation of the collaboration measures and controls (Long & Freese, 2014).

3.4.2. Strategic importance

Model A2 examines the ordered importance assigned to introducing new goods or services. The four response categories retain their natural ranking (not important, low, medium and high) without imposing equal distances between adjacent categories. The ordered logit model can be represented through an underlying latent variable:

$$Y_i^* = x_i'\beta + u_i \qquad (3.2)$$

The observed outcome $Y_i \in \{0, 1, 2, 3\}$ is determined by threshold parameters a_j:

$$Y_i = j \quad if \quad a_{j-1} < Y_i^* \leq a_j, \qquad j = 0, 1, 2, 3. \qquad (3.3)$$

Accordingly, the probability of observing category j is:

$$\Pr(Y_i = j \mid x_i) = F(a_j - x_i'\beta) - F(a_{j-1} - x_i'\beta). \qquad (3.4)$$

where $F(\cdot)$ denotes the logistic cumulative distribution function, with $\alpha_{-1} = -\infty$ and $\alpha_3 = +\infty$.

AMEs are computed for all four response categories. The model relies on the proportional-odds assumption, under which the slope coefficients are common across cumulative response thresholds (Long & Freese, 2014).

3.4.3. Product-innovation profile

Model A3 treats the product-innovation profile as a nominal three-category outcome. Multinomial logit is used because the values represent qualitatively different innovation profiles rather than a count of independent innovation events. The "neither category" profile (coded 0) is the reference outcome. For m ∈ {1, 2}:

$$log\{Pr(Profile_i = m) / Pr(Profile_i = 0)\} = a_m + \beta_{1m}Cooperation_i + \beta_{2m}Breadth_i + \gamma'_m X_i + \delta_{sm} + \lambda_{tm} \quad (3.5)$$

Separate parameter vectors are estimated for the "exactly one" and "both" profiles relative to the reference category, and AMEs are calculated for all three predicted outcomes. As with any multinomial logit, interpretation is subject to the independence-of-irrelevant-alternatives assumption, which is particularly relevant here because the categories are constructed from related innovation indicators (Long & Freese, 2014).

Table 3.7. Final model specifications

Model	Dependent variable	Response scale	Estimator	Reported probability measure
A1	Market-new product innovation	0/1 nominal	Binary logit	Average marginal effect on Pr(market-new product innovation = 1)
A2	Strategic importance of introducing new goods or services	0–3 ordered	Ordered logit	Average marginal effects for outcomes 0, 1, 2 and 3
A3	Product-innovation profile	0, 1 or 2 nominal	Multinomial logit; base = 0	Average marginal effects for outcomes 0, 1 and 2

Note. All models include cooperation for innovation, collaboration breadth, external R&D contracting, the tertiary-education category indicators, the two enterprise-group indicators, CAE-division effects and survey-wave effects. Robust standard errors are used, and the final pooled sample is N = 41,012.

4. Empirical Results

This chapter presents the econometric results for the three innovation-related outcomes defined in Section 3 and discusses them in relation to the hypotheses and the relevant literature. The analysis is organized by outcome: market-new product innovation, the strategic importance of introducing new goods or services, and the product-innovation profile. For each outcome, coefficient estimates are reported together with average marginal effects (AMEs), which provide the main basis for substantive interpretation on the probability scale. The final section assesses temporal robustness and sensitivity to the joint inclusion of cooperation participation and collaboration breadth. Given the repeated cross-sectional design, selection into cooperation, omitted firm characteristics and reverse causality remain plausible; the estimates are therefore interpreted as conditional associations rather than causal effects.

4.1. Market-new product innovation

Model A1 indicates positive conditional associations between both dimensions of collaboration and market-new product innovation. The binary-logit coefficient on cooperation for innovation is positive and statistically significant ($\beta = 1.075$, SE = 0.058, $p < .001$). On the probability scale, cooperation is associated with a 13.78 percentage-point higher average predicted probability of reporting market-new product innovation, after accounting for the remaining covariates and fixed effects. Collaboration breadth is likewise positively associated with the outcome ($\beta = 0.074$, SE = 0.009, $p < .001$), with an AME of 0.0072, equivalent to a 0.72 percentage-point increase for one additional partner-type/location combination.

Because cooperation represents a discrete change from non-cooperation to cooperation, whereas breadth is measured per additional partner-type/location combination, their AME magnitudes are not directly comparable. Breadth is also structurally zero for non-cooperating enterprises; the two estimates are therefore interpreted jointly as complementary features of the reported collaboration profile.

Table 4.1. Model A1: Binary-logit estimates and average marginal effects

Variable	Logit coefficient	AME on Pr(market-new product innovation = 1)
Cooperation for innovation (Yes)	1.075*** (0.058)	0.1378*** (0.0092)
Collaboration breadth (0–30)	0.074*** (0.009)	0.0072*** (0.0009)
External R&D contracting (Yes)	0.851*** (0.052)	0.1039*** (0.0077)
Tertiary education: 1% to <5%	0.734*** (0.081)	0.0471*** (0.0046)
Tertiary education: 5% to <10%	0.966*** (0.087)	0.0676*** (0.0057)
Tertiary education: 10% to <25%	1.163*** (0.084)	0.0875*** (0.0056)
Tertiary education: 25% to <50%	1.279*** (0.089)	0.1003*** (0.0065)
Tertiary education: 50% to <75%	1.446*** (0.093)	0.1205*** (0.0075)
Tertiary education: 75% or more	1.616*** (0.093)	0.1428*** (0.0079)
Group head office in Portugal (Yes)	0.181*** (0.041)	0.0183*** (0.0043)
Group head office abroad (Yes)	0.240*** (0.048)	0.0246*** (0.0052)
CAE Rev. 3 division effects	Included	Included
CIS-wave effects	Included	Included
Observations	41,012	41,012
Wald χ^2 (91)	4,373.97	—
Prob > χ^2	< .001	—
Pseudo R^2	0.1702	—

*Note. Logit coefficients and average marginal effects (AMEs) are reported with robust standard errors in parentheses; AME standard errors use the delta method. For binary indicators, AMEs are discrete changes from the reference category; the breadth AME refers to a one-unit increase. The reference category for tertiary education is 0%. CAE-division and CIS-wave coefficients are included but not displayed. *** p < .01; ** p < .05; * p < .10.*

Among the controls, external R&D contracting is positively associated with market-new product innovation (AME = 0.104, p < .001). Relative to enterprises reporting no employees with tertiary education, all six higher education categories have positive and statistically significant AMEs, ranging from 0.047 for the 1% to <5% category to 0.143 for the 75% or more category. The indicators for belonging to an enterprise group with a head office in Portugal or abroad are also positive and statistically significant, with AMEs of 0.018 and 0.025, respectively. These covariates are included primarily as controls rather than as the central objects of inference.

The positive cooperation and breadth associations are consistent with OI arguments that external engagement can expand firms' access to complementary knowledge and

capabilities and support innovation outcomes (Chesbrough, 2003; West & Bogers, 2014; Laursen & Salter, 2006). However, the breadth measure captures partner-type/location combinations rather than external-search breadth, and the specification estimates an average linear association rather than testing for diminishing returns. Subject to these qualifications, the pooled evidence supports H1a and H2a.

4.2. Strategic importance

Model A2 indicates positive associations between collaboration and the strategic importance attributed to introducing new goods or services. Both cooperation ($\beta = 0.432$, SE = 0.047, $p < .001$) and collaboration breadth ($\beta = 0.051$, SE = 0.008, $p < .001$) have positive and statistically significant ordered-logit coefficients. The AMEs show how these associations are distributed across the four response categories.

Table 4.2. Model A2: Ordered-logit estimates

Variable	Ordered-logit coefficient
Cooperation for innovation (Yes)	0.432*** (0.047)
Collaboration breadth (0–30)	0.051*** (0.008)
External R&D contracting (Yes)	0.324*** (0.039)
Tertiary education: 1% to <5%	0.357*** (0.031)
Tertiary education: 5% to <10%	0.488*** (0.037)
Tertiary education: 10% to <25%	0.651*** (0.036)
Tertiary education: 25% to <50%	0.798*** (0.041)
Tertiary education: 50% to <75%	0.865*** (0.046)
Tertiary education: 75% or more	1.011*** (0.048)
Group head office in Portugal (Yes)	−0.063** (0.025)
Group head office abroad (Yes)	0.006 (0.033)
CAE Rev. 3 division effects	Included
CIS-wave effects	Included
Observations	41,012
Wald χ^2 (91)	3,364.95
Prob > χ^2	< .001
Pseudo R^2	0.0355

*Note. Ordered-logit coefficients are reported with robust standard errors in parentheses. The reference category for tertiary education is 0%. CAE-division and CIS-wave coefficients are included but not displayed; threshold parameters are estimated but omitted from the table. *** p < .01; ** p < .05; * p < .10.*

Table 4.3. Model A2: Average marginal effects by response category

Variable	Not important	Low	Medium	High
Cooperation for innovation (Yes)	−0.0332*** (0.0032)	−0.0359*** (0.0038)	−0.0258*** (0.0040)	0.0948*** (0.0109)
Collaboration breadth (0–30)	−0.0045*** (0.0007)	−0.0044*** (0.0007)	−0.0017*** (0.0003)	0.0105*** (0.0017)
External R&D contracting (Yes)	−0.0256*** (0.0028)	−0.0271*** (0.0032)	−0.0175*** (0.0029)	0.0702*** (0.0088)
Tertiary education: 1% to <5%	−0.0407*** (0.0038)	−0.0324*** (0.0028)	0.0080*** (0.0014)	0.0651*** (0.0055)
Tertiary education: 5% to <10%	−0.0532*** (0.0042)	−0.0442*** (0.0033)	0.0059*** (0.0016)	0.0915*** (0.0070)
Tertiary education: 10% to <25%	−0.0671*** (0.0040)	−0.0586*** (0.0033)	−0.0004 (0.0018)	0.1261*** (0.0069)
Tertiary education: 25% to <50%	−0.0782*** (0.0043)	−0.0710*** (0.0036)	−0.0093*** (0.0023)	0.1585*** (0.0081)
Tertiary education: 50% to <75%	−0.0828*** (0.0045)	−0.0765*** (0.0039)	−0.0145*** (0.0028)	0.1739*** (0.0094)
Tertiary education: 75% or more	−0.0921*** (0.0045)	−0.0879*** (0.0040)	−0.0275*** (0.0035)	0.2075*** (0.0100)
Group head office in Portugal (Yes)	0.0056** (0.0023)	0.0054** (0.0022)	0.0019*** (0.0007)	−0.0129** (0.0052)
Group head office abroad (Yes)	−0.0005 (0.0029)	−0.0005 (0.0028)	−0.0002 (0.0011)	0.0012 (0.0069)

*Note. Entries are average marginal effects with robust delta-method standard errors in parentheses. The four columns correspond to the predicted probabilities of the four response categories. The reference category for tertiary education is 0%. N = 41,012. *** p < .01; ** p < .05; * p < .10. For binary and categorical indicators, AMEs are discrete changes from the relevant reference category; for collaboration breadth, the AME refers to a one-unit increase.*

Cooperation is associated with reductions of approximately 3.3, 3.6 and 2.6 percentage points in the probabilities of reporting "not important," "low" and "medium," respectively, and with a 9.48 percentage-point increase in Pr(high). For collaboration breadth, the corresponding AMEs are approximately −0.4, −0.4, −0.2 and +1.05 percentage points. The pattern therefore indicates a redistribution of predicted probability toward the highest strategic-importance category rather than a change confined to one adjacent category.

Among the controls, external R&D contracting is associated with a 7.02 percentage-point higher Pr(high). Relative to the 0% tertiary-education reference category, the six higher categories have positive ordered-logit coefficients and Pr(high) AMEs ranging from approximately 6.5 to 20.8 percentage points. Belonging to an enterprise group headquartered in Portugal is associated with a 1.29 percentage-point lower Pr(high), whereas the foreign-headed group indicator is not statistically significant.

The positive collaboration associations are consistent with the view that external engagement can form part of how firms organize innovation activities and strategic priorities (Chesbrough & Appleyard, 2007; West & Bogers, 2014). Because the outcome captures stated strategic importance rather than realized business performance, the results are

interpreted as associations with firms' strategic orientation and do not imply superior financial or market performance. The pooled evidence supports H1b and H2b.

4.3. Product-innovation profile

Model A3 examines the three nominal product-innovation profiles using "neither" as the reference category. The multinomial-logit coefficients are positive and statistically significant for cooperation in both the exactly-one-versus-neither comparison ($\beta = 1.216$, SE = 0.069, $p < .001$) and the both-versus-neither comparison ($\beta = 1.442$, SE = 0.075, $p < .001$). Collaboration breadth is also positive and statistically significant in both comparisons ($\beta = 0.052$, SE = 0.014, $p < .001$; $\beta = 0.122$, SE = 0.014, $p < .001$, respectively).

Table 4.4. Model A3: Multinomial-logit estimates

Variable	Exactly one vs. neither	Both vs. neither
Cooperation for innovation (Yes)	1.216*** (0.069)	1.442*** (0.075)
Collaboration breadth (0–30)	0.052*** (0.014)	0.122*** (0.014)
External R&D contracting (Yes)	1.161*** (0.057)	1.396*** (0.063)
Tertiary education: 1% to <5%	0.581*** (0.061)	0.849*** (0.092)
Tertiary education: 5% to <10%	0.884*** (0.067)	1.106*** (0.099)
Tertiary education: 10% to <25%	1.147*** (0.064)	1.347*** (0.096)
Tertiary education: 25% to <50%	1.129*** (0.070)	1.407*** (0.102)
Tertiary education: 50% to <75%	1.206*** (0.074)	1.578*** (0.107)
Tertiary education: 75% or more	1.376*** (0.075)	1.690*** (0.108)
Group head office in Portugal (Yes)	0.223*** (0.036)	0.214*** (0.047)
Group head office abroad (Yes)	0.290*** (0.044)	0.339*** (0.055)
CAE Rev. 3 division effects	Included	Included
CIS-wave effects	Included	Included
Observations	41,012	41,012
Wald χ^2 (182)	5,869.84	5,869.84
Prob > χ^2	< .001	< .001
Pseudo R^2	0.1427	0.1427

*Note. Multinomial-logit coefficients are reported with robust standard errors in parentheses. The reference outcome is neither product-innovation category. The reference category for tertiary education is 0%. CAE-division and CIS-wave coefficients are included but not displayed. *** p < .01; ** p < .05; * p < .10. Model-level statistics apply jointly to both outcome equations.*

Table 4.5. Model A3: Average marginal effects by outcome

Variable	Neither	Exactly one	Both
Cooperation for innovation (Yes)	−0.2558*** (0.0140)	0.1480*** (0.0116)	0.1078*** (0.0086)
Collaboration breadth (0–30)	−0.0121*** (0.0021)	0.0037** (0.0016)	0.0084*** (0.0009)
External R&D contracting (Yes)	−0.2405*** (0.0110)	0.1367*** (0.0097)	0.1038*** (0.0075)
Tertiary education: 1% to <5%	−0.0845*** (0.0062)	0.0461*** (0.0058)	0.0384*** (0.0045)
Tertiary education: 5% to <10%	−0.1301*** (0.0077)	0.0791*** (0.0071)	0.0509*** (0.0055)
Tertiary education: 10% to <25%	−0.1754*** (0.0076)	0.1114*** (0.0069)	0.0641*** (0.0053)
Tertiary education: 25% to <50%	−0.1767*** (0.0087)	0.1066*** (0.0078)	0.0701*** (0.0060)
Tertiary education: 50% to <75%	−0.1974*** (0.0096)	0.1129*** (0.0087)	0.0845*** (0.0069)
Tertiary education: 75% or more	−0.2267*** (0.0100)	0.1369*** (0.0091)	0.0898*** (0.0071)
Group head office in Portugal (Yes)	−0.0364*** (0.0055)	0.0250*** (0.0050)	0.0114*** (0.0039)
Group head office abroad (Yes)	−0.0518*** (0.0070)	0.0313*** (0.0063)	0.0205*** (0.0048)

*Note. Entries are average marginal effects with robust delta-method standard errors in parentheses. The three columns are predicted outcomes, not multinomial-logit coefficient comparisons. The reference category for tertiary education is 0%. N = 41,012. *** p < .01; ** p < .05; * p < .10. For binary and categorical indicators, AMEs are discrete changes from the relevant reference category; for collaboration breadth, the AME refers to a one-unit increase.*

The probability-scale results provide the substantive interpretation. Cooperation is associated with an approximately 25.6 percentage-point lower predicted probability of reporting neither category and with increases of 14.8 and 10.8 percentage points in the probabilities of reporting exactly one and both categories, respectively. For each additional breadth unit, the corresponding AMEs are approximately −1.2, +0.4 and +0.8 percentage points. As expected for mutually exclusive predicted probabilities, the three AMEs for each explanatory variable sum to approximately zero.

External R&D contracting is associated with a lower predicted probability of reporting neither category and higher probabilities of reporting exactly one and both categories. Relative to enterprises in the 0% tertiary-education category, all six higher education categories display the same directional pattern. The two enterprise-group indicators are likewise associated with lower predicted probabilities of neither and higher probabilities of the two innovation profiles. These controls account for observable differences in external research engagement, human capital and organizational structure but are not interpreted as direct measures of absorptive capacity.

The differentiated probability pattern in Model A3 is consistent with the literature's emphasis on heterogeneity in collaborative configurations and innovation outcomes (Belderbos et al., 2004; Laursen & Salter, 2006). In the pooled estimates, the breadth AME is larger for the both-category profile (0.0084) than for the exactly-one profile (0.0037), indicating that collaborative scope is not uniformly related to all product-innovation profiles. Because the three profiles are nominal, these differences concern the composition of reported innovation activity rather than an ordering of innovation performance.

The results indicate that interorganizational engagement is associated not only with a single innovation indicator but also with the composition of firms' reported product-innovation activity. The pooled specification therefore supports H1c and H2c: participation and breadth are each associated with a lower predicted probability of reporting neither category and higher probabilities of reporting exactly one and both categories. The robustness of these associations, particularly the breadth relationship with the exactly-one profile, is assessed in Section 4.4.

4.4. Robustness checks

4.4.1. Temporal robustness

To assess temporal robustness, Models A1–A3 were re-estimated separately for CIS 2018, 2020 and 2022 using the same outcomes, explanatory variables, controls and CAE-division effects as in the pooled analysis, while omitting wave indicators by construction. Full wave-specific coefficient estimates are reported in Annex I; Table 4.6 summarizes the focal AMEs with robust delta-method standard errors and effective sample sizes.

Before interpreting the wave-specific estimates, diagnostic checks do not indicate severe multicollinearity. Cooperation and collaboration breadth are correlated by construction ($r = 0.732$), while their VIFs are 2.34 and 2.30, respectively, and the mean VIF for the final set of regressors is 1.59. In the wave-specific A1 models, perfect prediction in sparse CAE categories reduces the effective samples to 13,604, 13,482 and 13,782 observations for 2018, 2020 and 2022, respectively. Stata additionally flags 20 completely determined observations in the CIS 2022 A3 robustness regression; the corresponding single-wave estimates are therefore interpreted with additional caution.

Table 4.6. Wave-specific average marginal effects for the principal associations

Marginal effect	CIS 2018	CIS 2020	CIS 2022
A1: Cooperation → Pr(market-new)	0.1270*** (0.0172)	0.1298*** (0.0163)	0.1494*** (0.0147)
A1: Breadth → Pr(market-new)	0.0084*** (0.0019)	0.0072*** (0.0017)	0.0069*** (0.0013)
A2: Cooperation → Pr(high)	0.0996*** (0.0208)	0.0839*** (0.0199)	0.0960*** (0.0164)
A2: Breadth → Pr(high)	0.0076** (0.0033)	0.0158*** (0.0034)	0.0088*** (0.0025)
A3: Cooperation → Pr(neither)	−0.2510*** (0.0274)	−0.2162*** (0.0244)	−0.2922*** (0.0220)
A3: Cooperation → Pr(exactly one)	0.1616*** (0.0228)	0.1164*** (0.0198)	0.1714*** (0.0188)
A3: Cooperation → Pr(both)	0.0894*** (0.0156)	0.0998*** (0.0152)	0.1208*** (0.0135)
A3: Breadth → Pr(neither)	−0.0130*** (0.0044)	−0.0150*** (0.0038)	−0.0097*** (0.0032)
A3: Breadth → Pr(exactly one)	0.0033 (0.0032)	0.0052* (0.0028)	0.0027 (0.0025)
A3: Breadth → Pr(both)	0.0097*** (0.0019)	0.0098*** (0.0017)	0.0070*** (0.0012)
A1 observations	13,604	13,482	13,782
A2/A3 observations	13,701	13,509	13,802

*Note. Entries are average marginal effects with robust delta-method standard errors in parentheses. Each wave-specific model retains the pooled controls and CAE-division effects and omits CIS-wave indicators. A1 effective samples reflect perfect prediction in sparse CAE categories. Stata also flags 20 completely determined observations in the CIS 2022 A3 model, which should therefore be interpreted with additional caution. *** p < .01; ** p < .05; * p < .10.*

The A1 associations are stable across waves. The cooperation AME ranges from 12.70 percentage points in 2018 to 14.94 percentage points in 2022, while the breadth AME ranges from approximately 0.69 to 0.84 percentage points; all estimates are statistically significant at the 1% level. For Model A2, cooperation is associated with increases of 9.96, 8.39 and 9.60 percentage points in the probability of the "high" category in 2018, 2020 and 2022, respectively. The corresponding breadth AMEs are 0.76, 1.58 and 0.88 percentage points and remain positive and statistically significant in all three waves.

Model A3 provides a more differentiated pattern. The cooperation AMEs retain the same direction across all three outcomes and waves. For breadth, the probability of reporting neither category decreases significantly in every wave, while the probability of reporting both categories increases significantly throughout. By contrast, the breadth AME for the exactly-one profile is small and not statistically significant at the 5% level in any individual wave; the 2020 estimate is significant only at the 10% level. The temporal robustness of the breadth association is therefore considerably stronger for the both-category profile than for the exactly-one profile.

4.4.2. Sensitivity to the joint specification of participation and breadth

A separate-specification sensitivity analysis yields the same broad substantive pattern as the joint pooled models. In the full sample, when cooperation is entered without breadth, it is associated with predicted probabilities of market-new product innovation and high strategic importance that are 19.0 and 14.3 percentage points higher, respectively (both $p < .01$). Among cooperating enterprises, a one-unit increase in breadth is associated with corresponding increases of 1.8 and 1.2 percentage points (both $p < .01$). Because the breadth-only models use the restricted sample of cooperating enterprises, their magnitudes should not be compared mechanically with those from the full-sample cooperation-only models.

Table 4.7. Sensitivity to estimating cooperation participation and collaboration breadth separately

Model / predicted outcome	Cooperation only	Breadth only
A1: Pr(market-new)	0.190*** (0.008)	0.018*** (0.002)
A2: Pr(high)	0.143*** (0.008)	0.012*** (0.002)
A3: Pr(neither)	−0.324*** (0.009)	−0.017*** (0.002)
A3: Pr(exactly one)	0.153*** (0.008)	−0.002 (0.002)
A3: Pr(both)	0.171*** (0.007)	0.019*** (0.002)
Observations — A1	41,012	4,525
Observations — A2/A3	41,012	4,552

*Note. Entries are average marginal effects with robust delta-method standard errors in parentheses. Cooperation-only models are estimated on the full analytical sample. Breadth-only models are restricted to cooperating enterprises. All specifications retain the controls and fixed effects used in the corresponding pooled model. The exercise is a sensitivity analysis and does not replace the joint specifications reported in Tables 4.1–4.5. *** p < .01; ** p < .05; * p < .10.*

The A3 sensitivity results provide a more differentiated pattern. In the cooperation-only specification, participation is associated with a 32.4-percentage-point lower predicted probability of reporting neither category and with 15.3- and 17.1-percentage-point higher probabilities of reporting exactly one and both categories, respectively (all $p < .01$). Among cooperating enterprises, a one-unit increase in breadth is associated with changes of −1.7, −0.2 and +1.9 percentage points in Pr(neither), Pr(exactly one) and Pr(both), respectively; the exactly-one AME is not statistically significant, whereas the other two are significant at the 1% level. This reinforces the main qualification to H2c: the breadth association with the both-category profile is robust to the separate specification, whereas the association with the exactly-one profile is not. Together with the wave-specific estimates, the evidence for H2c is therefore strongest for the probability of reporting both product-innovation categories.

5. Conclusion

5.1. Main findings and contribution

This dissertation examined how participation in innovation cooperation and collaboration breadth are associated with different innovation-related outcomes among Portuguese enterprises covered by the CIS. Drawing on the OI and ACAP literatures, it treated interorganizational collaboration as a heterogeneous form of external engagement and distinguished the occurrence of active cooperation from the scope of the reported collaboration network (Chesbrough, 2003; Cohen & Levinthal, 1990; West & Bogers, 2014). The pooled and robustness results provide a consistent answer to the research question: both dimensions are systematically associated with the three outcomes, although the magnitude and robustness of these associations vary across outcome definitions. This variation reinforces the value of distinguishing both collaboration dimensions and innovation outcomes rather than reducing either to a single indicator.

The empirical analysis pooled the Portuguese CIS 2018, 2020 and 2022 microdata as repeated cross-sections, covering 41,012 enterprise-wave observations. In the pooled models, participation in innovation cooperation is associated with a 13.78 percentage-point higher average predicted probability of introducing a market-new product innovation and a 9.48 percentage-point higher probability of assigning high strategic importance to introducing new goods or services. Collaboration breadth displays the same directional pattern: each additional partner-type/location combination is associated with increases of 0.72 and 1.05 percentage points in these probabilities, respectively. These findings indicate that interorganizational collaboration is associated both with a realized dimension of product innovation and with the strategic importance firms assign to innovation, while the latter remains conceptually distinct from realized business or financial performance.

The product-innovation profile provides a more differentiated picture. Participation in innovation cooperation is associated with a 25.58 percentage-point lower predicted probability of reporting neither product-innovation category and with increases of 14.80 and 10.78 percentage points in the probabilities of reporting exactly one and both categories, respectively. The corresponding breadth AMEs are −1.21, +0.37 and +0.84 percentage points for the neither, exactly-one and both profiles, respectively. Because these profiles are nominal rather than ordered outcomes, these differences describe the composition of firms' reported product-innovation activity and should not be interpreted as a hierarchy of

innovation performance. The magnitudes of the participation and breadth AMEs should not be compared mechanically, since participation represents a discrete change from non-cooperation to cooperation, whereas breadth represents a one-unit change in reported collaborative scope and is structurally zero for non-cooperating enterprises.

The wave-specific estimations broadly reinforce the pooled evidence for market-new product innovation and strategic importance, as well as for the main product-innovation profile results. The main exception concerns the breadth association with the exactly-one profile. Although the pooled AME is positive and statistically significant, the corresponding wave-specific estimates are not statistically significant at the 5% level in any individual CIS wave, with the 2020 estimate reaching only the 10% level. The separate-specification sensitivity analysis leads to the same qualification: among cooperating enterprises, breadth remains positively associated with the both-category profile but is not significantly associated with the exactly-one profile. At the pooled level, the evidence supports H1a–H1c and H2a–H2c. However, the temporal and specification robustness of H2c is clearly stronger for the profile reporting both product-innovation categories than for the exactly-one profile.

Taken together, the findings support a differentiated interpretation of the collaboration–innovation relationship. They are consistent with prior evidence linking external engagement to innovation while also showing that the observed pattern depends on how collaboration and innovation are operationalized (Laursen & Salter, 2006; Xie et al., 2023). In particular, the less robust breadth association with the exactly-one profile indicates that broader collaboration is not associated equally strongly with all configurations of reported product-innovation activity. This pattern is consistent with the literature emphasizing both the potential benefits and the organizational trade-offs of openness (Faems et al., 2010; Laursen & Salter, 2006).

The dissertation also extends the Portuguese evidence in several respects. It provides recent firm-level evidence across three harmonized CIS waves and a broad range of economic activities, rather than focusing on a single sector, firm population or survey period (Ademuyiwa et al., 2025; Almeida, 2021, 2024; Cesário & Fernandes, 2019; Fernandes et al., 2017); it distinguishes participation in innovation cooperation from the reported scope of collaborative relationships; and it examines both dimensions across three complementary innovation-related outcomes. In this sense, the contribution is deliberately more precise than a general claim that open innovation improves firm performance. The CIS cooperation variables capture one observable collaborative form of external engagement; accordingly, the

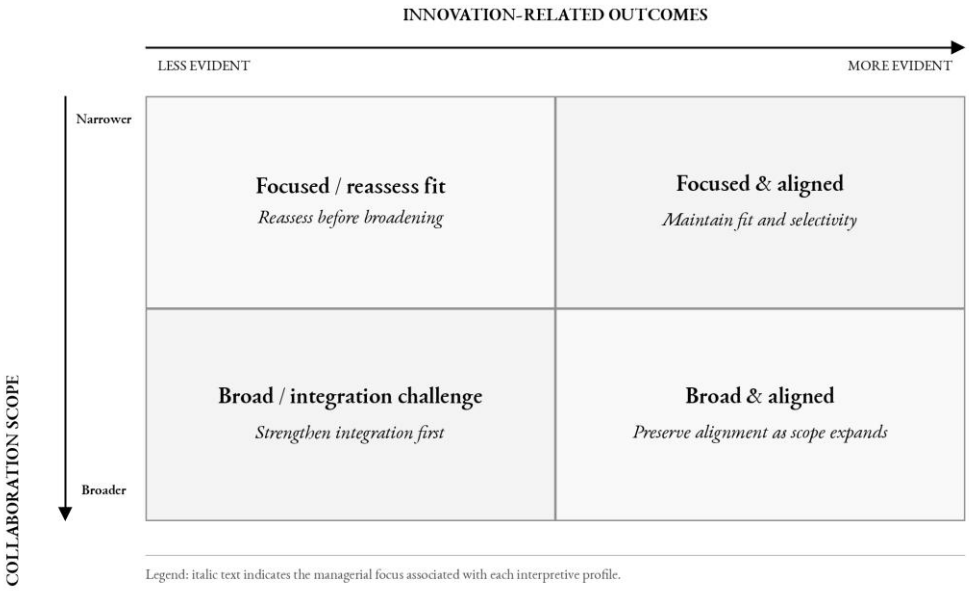
contribution concerns these measured collaboration constructs rather than open innovation as a whole.

5.2. Implications

The findings are consistent with the view that external collaboration is relevant not only to realized product innovation but also to the strategic importance firms assign to innovation. They should not, however, be translated into a simple recommendation to expand collaboration networks. The models estimate average conditional associations, breadth is structurally linked to participation, and the analysis does not identify an optimal number of partners. For managers, the results therefore suggest reviewing collaboration as a configuration that should remain aligned with the firm's knowledge needs and innovation objectives (Cohen & Levinthal, 1990; Faems et al., 2010).

This logic can be translated into the internal diagnostic matrix shown in Figure 5.1. The matrix is intended as a structured way of reviewing the configuration of collaboration rather than as a classification of firm performance.

Figure 5.1 Collaboration–Innovation Diagnostic Matrix



Note. *Illustrative managerial translation of the dissertation's empirical framework; not an empirically validated classification. The axes are relative, firm-specific assessments, no thresholds are estimated, and the matrix does not imply causality or that greater collaboration breadth is necessarily preferable.*

Source: *Author's elaboration based on the empirical framework developed in the present study.*

Used periodically, the matrix can help managers distinguish between two questions: whether broader external engagement is warranted and whether existing relationships are

being selected, coordinated and integrated effectively. A narrower collaboration scope combined with less evident innovation-related outcomes suggests reviewing partner fit, internal knowledge-related resources and timing before assuming that more partners are required. When a narrower scope coincides with more evident outcomes, existing relationships may already be sufficiently aligned with the firm's innovation objectives, suggesting a focus on preserving fit and selectivity.

With a broader collaboration scope, less evident outcomes suggest examining partner relevance, coordination demands and the firm's ability to integrate external knowledge before further expansion. Where broader collaboration is accompanied by more evident outcomes, the focus may instead be on maintaining selectivity and ensuring that knowledge-related resources remain adequate as scope expands. Across the four situations, the practical message is alignment rather than maximization: the dissertation does not identify an optimal collaboration breadth.

A practical one-page template for applying this diagnostic within firms is provided in Appendix G. At the policy and business-support level, the findings likewise caution against treating the number or breadth of collaborative relationships as a standalone indicator of innovation performance. Support initiatives may instead consider collaboration alongside partner relevance, firms' knowledge-related resources and the innovation objectives being pursued. Because the estimates are observational and unweighted, however, the present analysis does not identify the effects of particular policy interventions or provide population-representative estimates. The diagnostic should therefore be understood as an internal management aid for structuring review and discussion rather than as a prescriptive rule for allocating resources.

5.3. Limitations and directions for future research

The principal limitations arise from the observational and repeated cross-sectional nature of the data. Firms cannot be reliably followed across CIS waves, preventing within-firm analysis and control for time-invariant unobserved firm characteristics. Selection into innovation cooperation, omitted firm characteristics and reverse causality therefore remain plausible, and temporal ordering between collaboration and the reported outcomes cannot be established. The estimated relationships should consequently be interpreted as conditional associations rather than causal effects (Wooldridge, 2010). In addition, because survey weights are not applied, the estimates are not presented as population-representative estimates for Portuguese enterprises.

Measurement choices introduce additional limitations. Collaboration breadth is structurally linked to participation because it is observed through the cooperation module and is zero for non-cooperating enterprises (European Commission & Eurostat, n.d., 2018, 2022); this limits its interpretation as a fully independent dimension of collaboration. The tertiary-education measure is observed in relatively broad percentage categories (European Commission & Eurostat, n.d., 2018, 2022); although the final specifications correctly enter these categories as separate indicators rather than imposing a linear score, they remain a coarse measure of firms' human-capital composition. The product-innovation profile likewise combines two related CIS novelty indicators into three nominal categories and therefore provides a parsimonious characterization rather than a complete representation of firms' innovation activity.

The categorical-outcome models also rely on specification assumptions. The ordered-logit model assumes proportional odds across cumulative response thresholds, while the multinomial-logit model relies on the independence-of-irrelevant-alternatives (IIA) assumption (Long & Freese, 2014). The proportional-odds assumption could not be formally evaluated with the diagnostic commands available in the authorized research environment and therefore remains an explicit limitation rather than an empirically verified property of Model A2. The IIA assumption was likewise not formally tested in the final diagnostic workflow and is therefore treated as a maintained assumption of Model A3.

The available CIS information also limits the constructs that can be examined directly. Absorptive capacity is used as a theoretical lens rather than estimated as a mediating mechanism, since the available variables capture only selected aspects of external research access and human capital. The initial research scope also considered broader strategic and financial performance, but the harmonized CIS waves do not provide sufficiently comparable measures of these constructs without relying on indirect proxies and stronger interpretative assumptions. The analysis therefore focuses on innovation-related outcomes that are observed consistently across CIS 2018, 2020 and 2022.

The broad cross-industry and national scope also implies that the study does not estimate sector-specific or regional differences in the collaboration–innovation relationship. CAE-division effects account for systematic sector differences in the pooled models, but they do not test whether the collaboration coefficients themselves vary across economic activities. Similarly, the study is not designed as a regional comparison. These choices are consistent with the objective of providing broad cross-industry evidence within the

Portuguese CIS, but more disaggregated analyses could reveal heterogeneity that the present framework does not identify.

Although the CIS separately identifies the introduction of new or improved goods and services, the subsequent market-novelty indicators refer to product innovation in the CIS sense and do not identify whether market novelty arises specifically from goods or services (European Commission & Eurostat, n.d., 2018, 2022; OECD/Eurostat, 2018). The present models therefore cannot decompose the market-novelty outcomes by product type.

Future research could address these limitations through longitudinal firm identifiers, administrative-data linkages or research designs with stronger temporal ordering, allowing changes within firms and the sequencing of collaboration and innovation outcomes to be studied more directly. More detailed measures could also permit a direct examination of absorptive capacity and of the mechanisms through which firms integrate external knowledge.

The collaboration construct could be extended by distinguishing partner types and geographical locations, examining nonlinear relationships in breadth and testing whether the observed associations differ across sectors or regions. Such analyses would help determine whether the average relationships identified here conceal meaningful heterogeneity across collaboration configurations and economic contexts. Service innovation could also be examined separately using the available service-introduction indicators, while more detailed data would be required to distinguish service-specific market novelty.

Overall, the pooled evidence from the Portuguese CIS 2018–2022 indicates that participation in innovation cooperation and collaboration breadth are associated with all three innovation-related outcomes examined in this dissertation, although the robustness of these associations varies across outcome profiles. The consistency of the market-novelty and strategic-importance results, together with the more differentiated pattern across product-innovation profiles, reinforces the value of treating both collaboration and innovation as multidimensional. The dissertation therefore contributes a more precise account of collaborative innovation among Portuguese enterprises covered by the CIS: participation and collaborative scope are both empirically relevant, but the pattern and robustness of their associations depend on the outcome considered. Within these limits, the study provides recent firm-level evidence that connects the Portuguese context with the broader literature on open innovation and interorganizational collaboration.

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Appendices

The appendices provide supplementary conceptual, visual and applied material supporting the literature review and the managerial implications developed in the main text.

Appendix A — Innovation: definitions, typologies, and degrees of novelty

Table A1

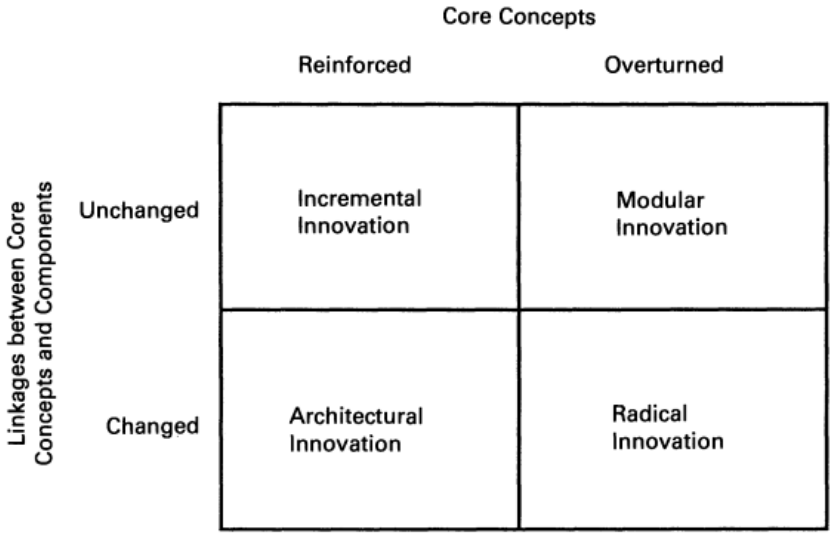
Comparing Types of Innovation across the Current and Previous Oslo Manual Editions.

OM3	*OM3* subcomponents	*OM4*[1]	Differences
Product	Goods Services	Goods Services Goods and services include knowledge-capturing products, and combinations thereof. Includes the design characteristics of goods and services.	Inclusion of product design characteristics, which were included under marketing innovation in OM3.
Process	Production Delivery and logistics Ancillary services, including purchasing, accounting and ICT services	Production Distribution and logistics Information and communication systems	Ancillary services in *OM3* moved to administration and management.
Organisational	Business practices Workplace organisation (distribution of responsibilities) External relations	Administration and management	Organisational innovations in *OM3* are under administration and management subcategories a, b and f in this edition of the manual. Ancillary services in administration and management (subcategories c, d, and e) were included under process innovation in *OM3*.
Marketing	Design of products Product placement and packaging Product promotion Pricing	Marketing, sales and after-sales support	Marketing innovations in *OM3* are included under subcategories a and b in this manual. Innovations in sales, after-sales services, and other customer support functions were not included in *OM3*. Innovations related to product design are included under product innovation in this manual.
N/A	N/A	Product and business process development	Not explicitly considered in *OM3* , most likely reported as Process innovation.

Note. *OM3 refers to the third edition of the Oslo Manual, published in 2005, whereas OM4 refers to the fourth edition. From OECD/Eurostat (2018, Table 3.2, p. 75).*

Figure A1

A Framework for Defining Innovation.

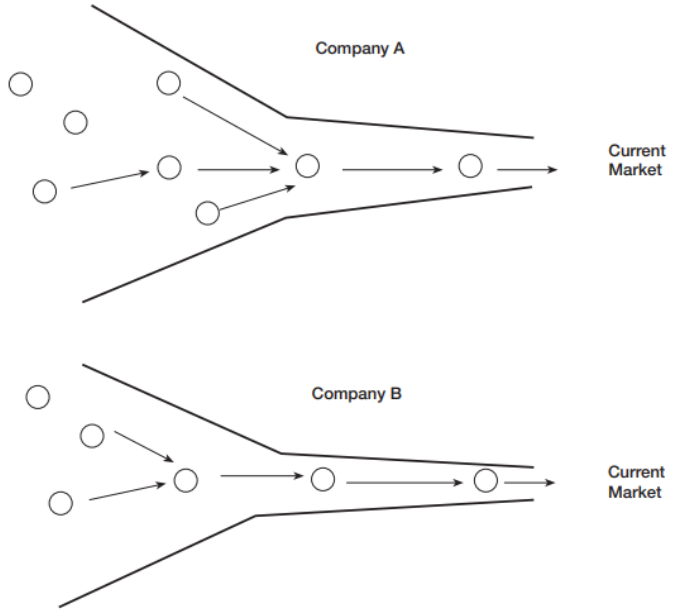


Note. *From Henderson and Clark (1990, Figure 1, p. 12).*

Appendix B — From closed to open innovation: knowledge flows

Figure B1

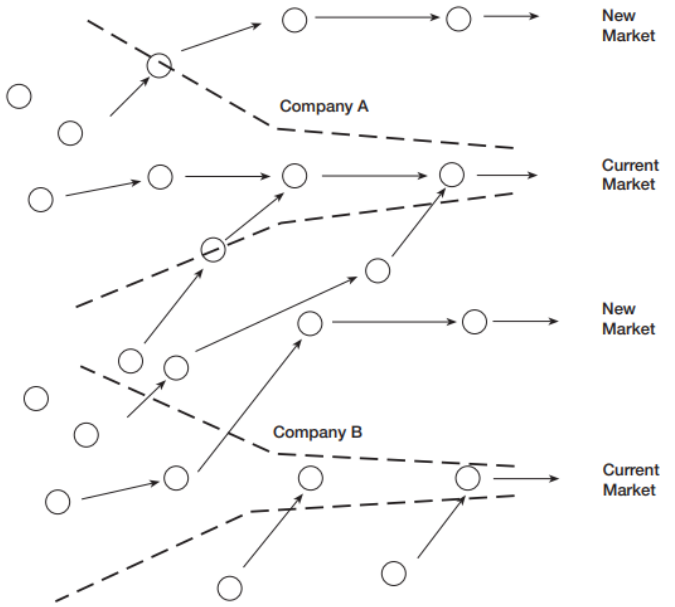
The knowledge landscape in closed innovation.



Note. *From Chesbrough (2003, Figure 2-1, p. 31).*

Figure B2

The knowledge landscape in the open innovation paradigm.



Note. *From Chesbrough (2003, Figure 3-1, p. 44).*

Appendix C — Trade-offs of Open Innovation

Table C1

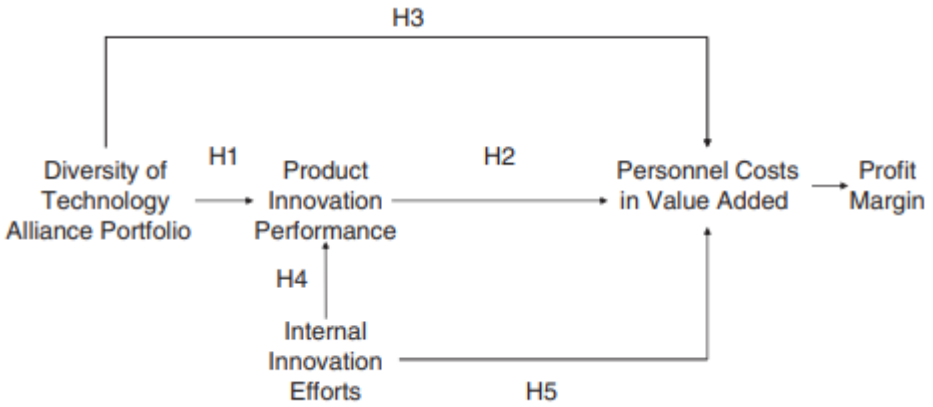
Comparison of four different types of openness.

	Outbound innovation Revealing	Outbound innovation Selling	Inbound innovation Sourcing	Inbound innovation Acquiring
Logic of exchange	Non-pecuniary—indirect benefits	Pecuniary—money involved in exchange	Non-pecuniary—indirect benefits	Pecuniary—money involved in exchange
Focus	Revealing internal resources to the external environment (e.g. Allen, 1983; Henkel, 2006; Nuvolari, 2004; von Hippel and von Krogh, 2003)	Out-licensing or selling products in the market place (e.g. Lichtenthaler and Ernst, 2009; Chesbrough and Rosenbloom, 2002)	Sourcing external ideas and knowledge from suppliers, customers, competitors, consultants, universities, public research organizations, etc. (e.g. Fey and Birkinshaw, 2005; Lakhani et al., 2006; Laursen and Salter, 2006a)	Acquiring inventions and input to the innovative process through informal and formal relationships (e.g. Chesbrough and Crowther, 2006; Christensen et al., 2005)
Advantages and disadvantages shaping extent of openness				
Advantages driving openness	Marshal resources and support (Henkel, 2006)	Commercialize products that are 'on the shelf'	Access to a wide array of ideas and knowledge (Laursen and Salter, 2006a)	Gaining access to resources and knowledge of partners (Powell et al., 1996)
	Gaining legitimacy from external environment (Nuvolari, 2004)	Outside partners may be better equipped to commercialize inventions to the mutual interests of both organizations (Chesbrough and Rosenbloom, 2002)	Discovering radical new solutions to solving problems (Lakhani et al., 2006)	Leveraging complementarities with partners (Dyer and Singh, 1998)
	Foster incremental and cumulative innovation (Murray and O'Mahony, 2007; Scotchmer, 1991)			
Disadvantages driving closeness	Difficult to capture the benefits that accrue	Over-commitment to own product and technologies make it difficult to out-license (Lichtenthaler and Ernst, 2007)	Many sources create an attention problem (Laursen and Salter, 2006a)	Difficult to maintain a large number of ties with different partners (Ahuja, 2000)
	Internal resources can leak to competitors (Laursen and Salter, 2006b)		Difficult to choose and combine between too many alternatives (Sapienza et al., 2004)	Risk of outsourcing critical dimension of the firm's business

Note. *From Dahlander and Gann (2010, Table 5, p. 706). Citation suffixes reproduced within the original table follow Dahlander and Gann (2010). Their "Laursen and Salter (2006a)" refers to the Strategic Management Journal article cited in this dissertation as Laursen and Salter (2006). For the appropriability argument associated with their "2006b" working-paper citation, the present dissertation uses Laursen and Salter (2014).*

Figure C1

Conceptual framework linking open innovation, innovation performance, and firm performance.

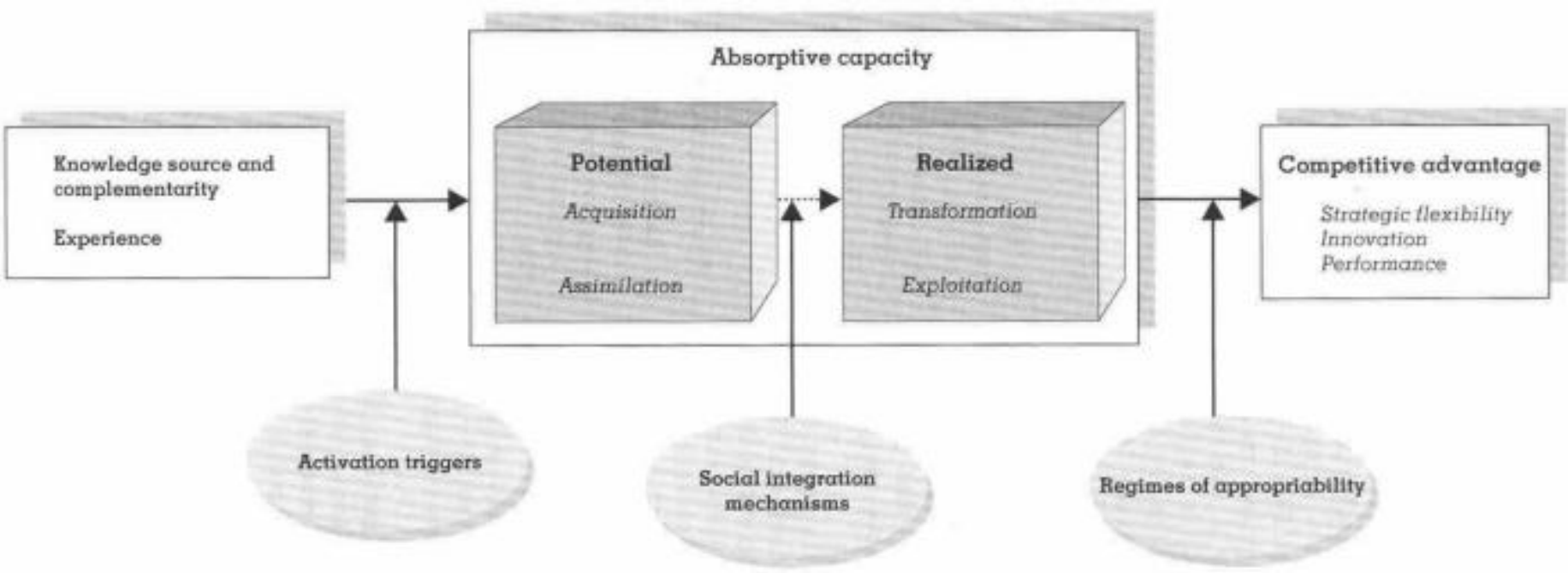


Note. *From Faems et al. (2010). Hypothesis labels H1–H5 refer to the conceptual framework of Faems et al. (2010) and are not the hypotheses tested in the present dissertation.*

Appendix D — Absorptive capacity as a dynamic capability

Figure D1

A model of absorptive capacity (ACAP).

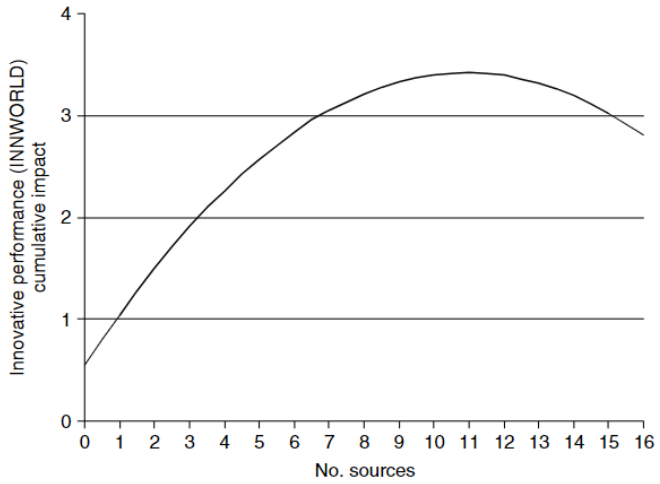


Note. *From Zahra and George (2002, Figure 1, p. 192).*

Appendix E — Empirical patterns of open innovation and collaboration

Figure E1

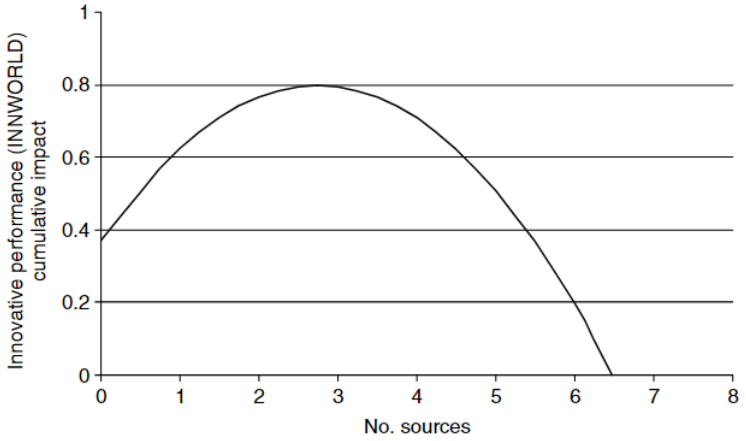
Predicted relationship between innovative performance and the breadth of search through external sources of innovation



Note. *From Laursen and Salter (2006, Figure 1, p. 143). The breadth and depth constructs reported by Laursen and Salter (2006) refer to external knowledge search and are not identical to the CIS collaboration-breadth measure used in the present dissertation.*

Figure E2

Predicted Relationship between Innovative Performance and the depth of search through external sources of innovation



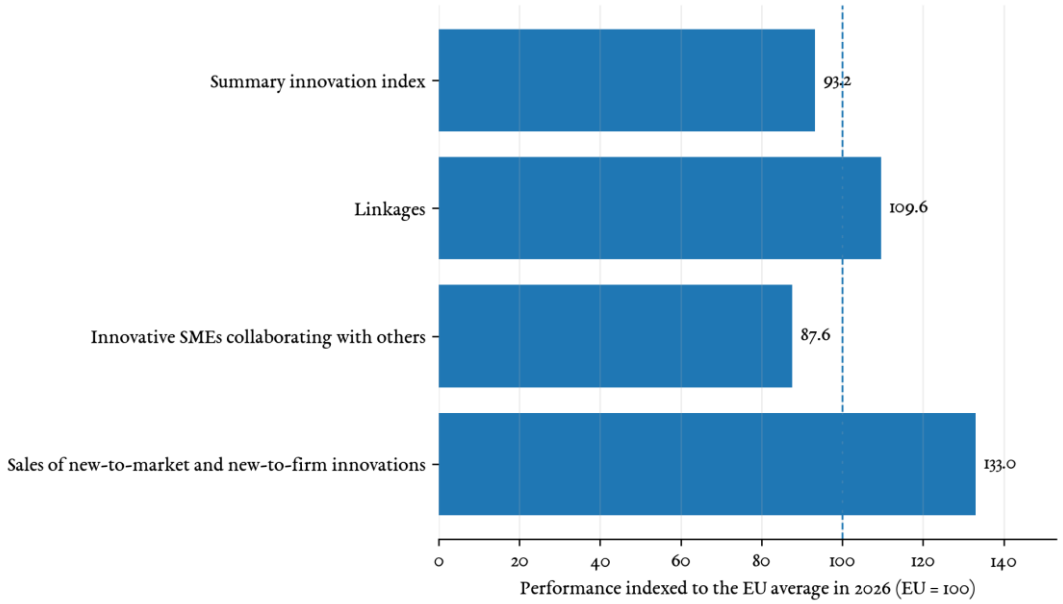
Note. *From Laursen and Salter (2006, Figure 2, p. 145). The breadth and depth constructs reported by Laursen and Salter (2006) refer to external knowledge search and are not identical to the CIS collaboration-breadth measure used in the present dissertation.*

Appendix F — Institutional indicators on innovation and collaboration in Portugal

This appendix complements Section 2.5.2 by presenting selected institutional indicators from the European Innovation Scoreboard 2026 for Portugal. These indicators provide national contextual evidence on innovation and collaborative linkages and should not be interpreted as direct measures of the firm-level cooperation constructs used in the empirical analysis.

Figure F1

Selected innovation and collaboration indicators for Portugal relative to the EU average, 2026.



Note. *Performance scores are indexed to the EU average in 2026 (= 100). Linkages is an aggregate EIS dimension, whereas Innovative SMEs collaborating with others is a specific indicator within that dimension. Author's elaboration based on European Commission (2026, p. 2).*

Table F1

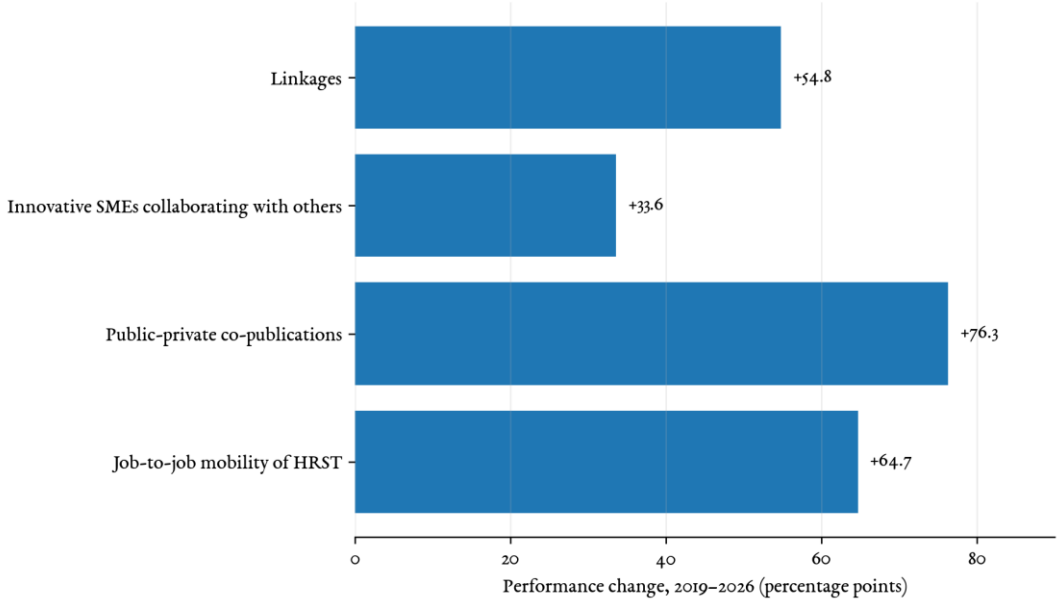
Linkages dimension and underlying indicators for Portugal, 2026.

Dimension / indicator	Performance indexed to EU in 2026	Rank among EU Member States
Linkages	109.6	16
Innovative SMEs collaborating with others	87.6	17
Public-private co-publications	161.2	15
Job-to-job mobility of HRST	104.2	13

Note. *The aggregate Linkages score is reported separately from its three underlying indicators in the EIS country profile. Scores are indexed to the EU average in 2026 (= 100). Author's elaboration based on European Commission (2026, p. 2).*

Figure F2

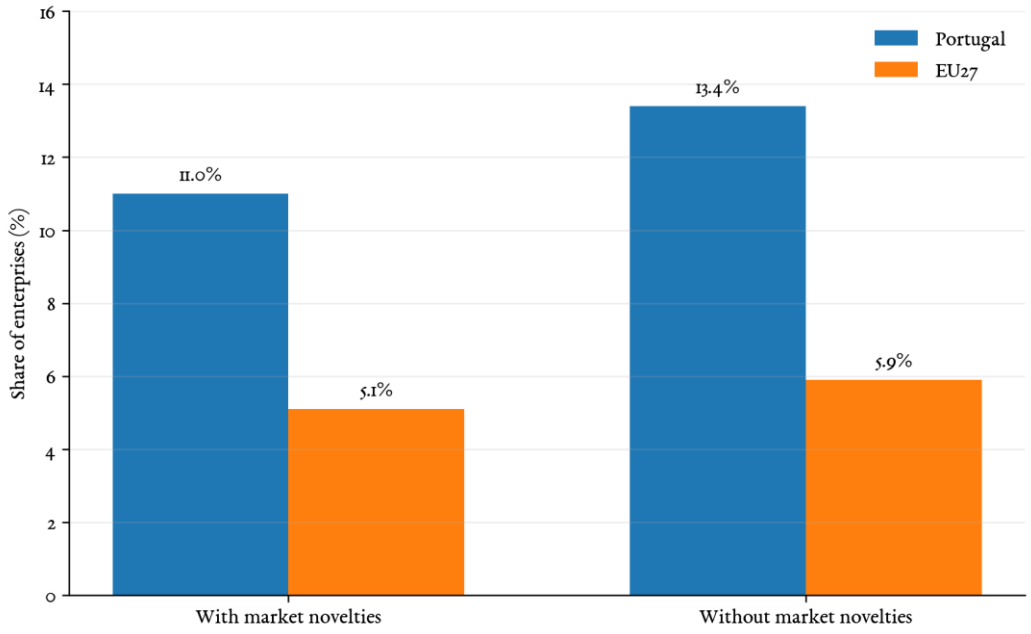
Longer-term change in the Linkages dimension and its underlying indicators, Portugal, 2019–2026.



Note. *Values are percentage-point changes in indexed performance between 2019 and 2026, as reported in the Performance Trends table of the Portugal country profile. Author's elaboration based on European Commission (2026, p. 3).*

Figure F3

In-house product innovators by market-novelty profile: Portugal and EU27.



Note. *The Structural Differences table reports 11.0% of Portuguese enterprises as in-house product innovators with market novelties, compared with 5.1% for the EU27, and 13.4% as in-house product innovators without market novelties, compared with 5.9% for the EU27. The country profile reports these innovation-profile data for 2022. Author's elaboration based on European Commission (2026, p. 6).*

Appendix G — Collaboration–Innovation Diagnostic: Managerial One-Page Template

Purpose. This template translates Section 5.2 and Figure 5.1 into a structured internal review. It is illustrative only.

Firm / unit: _____	Review date: _____	Reviewer: _____

A. Diagnostic profile

Dimension	Indicator	Internal review
Collaboration profile	Participation in innovation cooperation	Active cooperation on R&D or other innovation activities: Yes / No
	Collaboration breadth	Active partner-type/location combinations in the CIS cooperation grid: ____ / 30 Scope notes: _____
Knowledge-related resources	External R&D contracting	R&D contracted to enterprises or research organizations: Yes / No
	Share of persons employed with tertiary education	0% | 1–<5% | 5–<10% | 10–<25% | 25–<50% | 50–<75% | 75% or more
Innovation-related outcomes	Market-new product innovation	New or improved product not previously offered by competitors: Yes / No
	Strategic importance of introducing new goods or services	Not important / Low / Medium / High
	Product-innovation profile	Neither / Exactly one / Both CIS product-innovation categories

Interpretation note. *The knowledge-related indicators are the selected proxies used in the empirical models and are not direct measures of absorptive capacity.*

B. Management review

Alignment	Are current external relationships aligned with the firm's knowledge needs and innovation objectives?	Assessment / action: _____
Scope & integration	Would broader collaboration address a specific knowledge or capability need, or should partner relevance, coordination and knowledge integration be reviewed first?	Assessment / action: _____
Priority action	What should be maintained, reviewed or monitored next?	Assessment / action: _____

Source. Author's elaboration based on the empirical framework developed in the present study.

Annexes

Annex I — Full wave-specific robustness estimates

This annex reports the complete coefficient estimates from the wave-specific robustness models summarized through average marginal effects in Section 4.4.1. Each specification retains the controls and CAE Rev. 3 division effects used in the corresponding pooled model, while CIS-wave indicators are omitted by construction.

Table I.1. Model A1 robustness checks by CIS wave

Variable	CIS 2018	CIS 2020	CIS 2022
Cooperation for innovation (Yes)	1.028*** (0.111)	0.998*** (0.102)	1.165*** (0.092)
Collaboration breadth (0–30)	0.089*** (0.020)	0.071*** (0.017)	0.071*** (0.014)
External R&D contracting (Yes)	0.984*** (0.098)	0.972*** (0.090)	0.662*** (0.087)
Tertiary education: 1% to <5%	0.944*** (0.139)	0.683*** (0.138)	0.547*** (0.145)
Tertiary education: 5% to <10%	1.198*** (0.149)	0.937*** (0.151)	0.744*** (0.155)
Tertiary education: 10% to <25%	1.367*** (0.147)	1.142*** (0.145)	0.975*** (0.147)
Tertiary education: 25% to <50%	1.423*** (0.158)	1.274*** (0.152)	1.132*** (0.155)
Tertiary education: 50% to <75%	1.531*** (0.167)	1.491*** (0.157)	1.282*** (0.162)
Tertiary education: 75% or more	1.782*** (0.170)	1.653*** (0.156)	1.410*** (0.163)
Group head office in Portugal (Yes)	0.304*** (0.074)	0.216*** (0.069)	0.058 (0.072)
Group head office abroad (Yes)	0.287*** (0.087)	0.306*** (0.083)	0.156* (0.083)
CAE Rev. 3 division effects	Included	Included	Included
Observations	13,604	13,482	13,782
Wald χ^2 (df)	1,411.79 (86)	1,479.51 (86)	1,581.10 (87)
Prob > χ^2	< .001	< .001	< .001
Pseudo R^2	0.1786	0.1720	0.1725

*Note. Binary-logit coefficients are reported with robust standard errors in parentheses. The reference category for tertiary education is 0%. CAE Rev. 3 division effects are included, whereas CIS-wave indicators are omitted by construction. Effective sample sizes are reduced by perfect prediction in sparse CAE categories. *** p < .01; ** p < .05; * p < .10.*

Table I.2. Model A2 robustness checks by CIS wave

Variable	CIS 2018	CIS 2020	CIS 2022
Cooperation for innovation (Yes)	0.458*** (0.091)	0.379*** (0.087)	0.443*** (0.072)
Collaboration breadth (0–30)	0.037** (0.016)	0.075*** (0.016)	0.043*** (0.012)
External R&D contracting (Yes)	0.472*** (0.076)	0.322*** (0.070)	0.233*** (0.060)
Tertiary education: 1% to <5%	0.450*** (0.052)	0.353*** (0.055)	0.272*** (0.057)
Tertiary education: 5% to <10%	0.628*** (0.062)	0.507*** (0.067)	0.331*** (0.066)
Tertiary education: 10% to <25%	0.772*** (0.062)	0.613*** (0.065)	0.572*** (0.064)
Tertiary education: 25% to <50%	0.880*** (0.073)	0.822*** (0.071)	0.697*** (0.071)
Tertiary education: 50% to <75%	0.873*** (0.084)	0.861*** (0.079)	0.852*** (0.079)
Tertiary education: 75% or more	1.165*** (0.095)	1.008*** (0.080)	0.903*** (0.081)
Group head office in Portugal (Yes)	−0.069 (0.046)	−0.046 (0.044)	−0.068 (0.042)
Group head office abroad (Yes)	−0.041 (0.061)	0.026 (0.058)	0.037 (0.053)
CAE Rev. 3 division effects	Included	Included	Included
Observations	13,701	13,509	13,802
Wald χ^2 (df)	1,167.71 (88)	1,157.06 (87)	1,174.16 (88)
Prob > χ^2	< .001	< .001	< .001
Pseudo R^2	0.0377	0.0381	0.0349

*Note. Ordered-logit coefficients are reported with robust standard errors in parentheses. The reference category for tertiary education is 0%. CAE Rev. 3 division effects are included, whereas CIS-wave indicators are omitted by construction. Threshold parameters are estimated but not displayed. *** p < .01; ** p < .05; * p < .10.*

Table I.3. Model A3 robustness checks by CIS wave

Variable	CIS 2018	CIS 2020	CIS 2022
Exactly one vs. neither			
Cooperation for innovation (Yes)	1.315*** (0.137)	1.031*** (0.124)	1.320*** (0.105)
Collaboration breadth (0–30)	0.056* (0.031)	0.068*** (0.025)	0.040** (0.020)
External R&D contracting (Yes)	1.522*** (0.113)	1.286*** (0.098)	0.847*** (0.090)
Tertiary education: 1% to <5%	0.681*** (0.104)	0.645*** (0.110)	0.423*** (0.105)
Tertiary education: 5% to <10%	0.971*** (0.114)	0.971*** (0.121)	0.722*** (0.113)
Tertiary education: 10% to <25%	1.193*** (0.111)	1.257*** (0.117)	1.018*** (0.108)
Tertiary education: 25% to <50%	1.024*** (0.125)	1.223*** (0.125)	1.120*** (0.116)
Tertiary education: 50% to <75%	1.147*** (0.136)	1.179*** (0.132)	1.262*** (0.122)
Tertiary education: 75% or more	1.273*** (0.141)	1.527*** (0.130)	1.300*** (0.123)
Group head office in Portugal (Yes)	0.285*** (0.068)	0.198*** (0.064)	0.194*** (0.059)
Group head office abroad (Yes)	0.265*** (0.083)	0.355*** (0.077)	0.255*** (0.073)

Table I.3. Model A3 robustness checks by CIS wave (continued)

Variable	CIS 2018	CIS 2020	CIS 2022
Both vs. neither			
Cooperation for innovation (Yes)	1.343*** (0.148)	1.250*** (0.130)	1.670*** (0.120)
Collaboration breadth (0–30)	0.142*** (0.031)	0.135*** (0.025)	0.105*** (0.021)
External R&D contracting (Yes)	1.776*** (0.122)	1.488*** (0.108)	1.080*** (0.104)
Tertiary education: 1% to <5%	1.045*** (0.158)	0.845*** (0.155)	0.624*** (0.169)
Tertiary education: 5% to <10%	1.349*** (0.169)	1.099*** (0.169)	0.859*** (0.180)
Tertiary education: 10% to <25%	1.500*** (0.167)	1.413*** (0.162)	1.138*** (0.172)
Tertiary education: 25% to <50%	1.513*** (0.179)	1.430*** (0.173)	1.274*** (0.181)
Tertiary education: 50% to <75%	1.668*** (0.189)	1.638*** (0.179)	1.418*** (0.190)
Tertiary education: 75% or more	1.848*** (0.195)	1.781*** (0.179)	1.443*** (0.191)
Group head office in Portugal (Yes)	0.411*** (0.083)	0.207*** (0.078)	0.048 (0.083)
Group head office abroad (Yes)	0.375*** (0.099)	0.354*** (0.093)	0.306*** (0.095)
CAE Rev. 3 division effects	Included	Included	Included
Observations	13,701	13,509	13,802
Wald χ^2 (df)	8,560.95 (176)	11,042.97 (174)	12,733.53 (176)
Prob > χ^2	< .001	< .001	< .001
Pseudo R^2	0.1533	0.1423	0.1459

*Note. Multinomial-logit coefficients are reported with robust standard errors in parentheses. The reference outcome is neither product-innovation category, and the reference category for tertiary education is 0%. CAE Rev. 3 division effects are included, whereas CIS-wave indicators are omitted by construction. Model-level statistics apply jointly to both outcome equations. Stata flags 20 completely determined observations in the CIS 2022 model; that single-wave estimate should therefore be interpreted with additional caution. *** p < .01; ** p < .05; * p < .10.*

Annex II — Composition of the exactly-one product-innovation profile

Table II.1. Composition of the exactly-one product-innovation profile

Product-innovation category reported	Frequency	Percent
Only new-to-market product innovation	1,285	17.24%
Only new-to-enterprise product innovation	6,168	82.76%
Total	**7,453**	**100.00%**

Note. The table decomposes the 7,453 observations classified in the exactly-one product-innovation profile (INNOV_STRAT = 1). Percentages are calculated within this profile.